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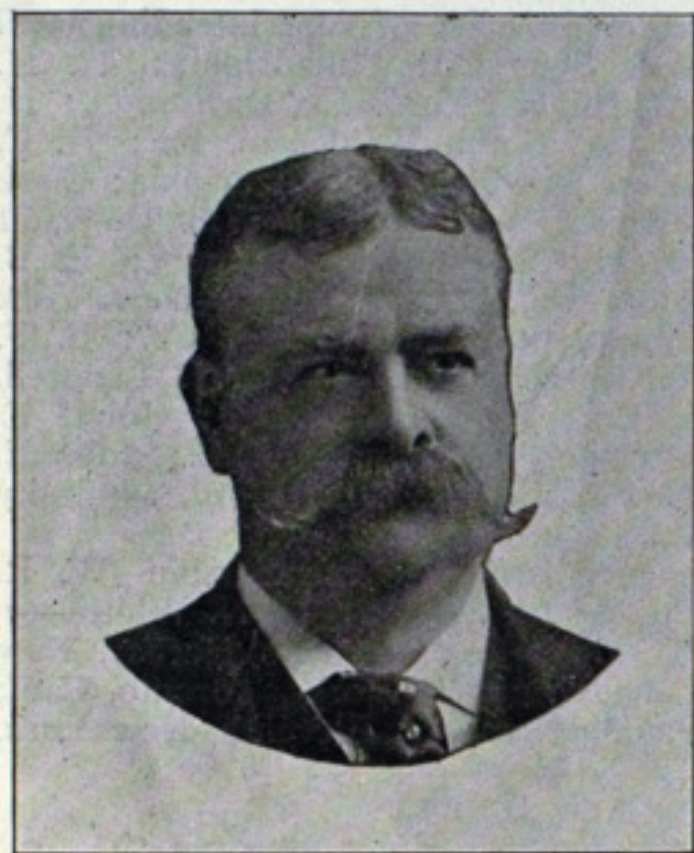
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No. 22

Naval Architects and Marine Engineers.

The tenth annual meeting of the Society of Naval Architects and Marine Engineers opened in the rooms of the Society of Mechanical Engineers, No. 12 West Thirty-first Street, New York, on Thursday morning, Nov. 20, with a more than usually large attendance for the opening session. President Clement A. Griscom presided and called the meeting to order. Secretary Washington L. Capps read his annual report showing that in



President Clement A. Griscom.

the society now there are 431 members, 320 associates, eighty-four juniors, five life members and three associates, a total of 843.

The receipts of the society, mainly in dues and the sale of printed proceedings, aggregated \$6,004.73 for the year ended with the 17th of the present month; at the opening of the year there was a balance on hand of \$1,238.43; total, \$7,243.16. Expenditures for the year just closed foot up \$5,459.91, leaving a balance of \$1,783.25. A statement of resources of the society is as follows: Membership fees due from members after deducting doubtful accounts (\$200.00) \$794.00;

due from dealers for volumes, \$337.98; publications on hand as per inventory, \$5,361.65; office furniture, \$80.00; cash in bank, \$1,714.69; cash on hand, \$68.56; investment in bond, \$5,102.38; certificate of deposit, \$3,000.00; total \$16,459.26.

Secretary Capps announced that the council recommended that the dues of the members and associates be made \$10 per annum with an entrance fee of \$10 and that the dues and entrance fees of juniors be placed at \$5. The dues and entrance fees of members and associates had been \$5 in each case. The question of increasing them had been submitted to a poll of the society and had received the indorsement of 458 members, as against ninety-nine who had voted against the increase. Admiral Bowles thought that a large proportion of the professional element would hesitate over the difference between \$5 and \$10. He offered as an amendment that the dues and entrance fees be made \$7.50 in each case. Admiral Bowles related that the average income from dues now amounted to about \$3,500 a year, but that owing to the growth of the society and the changed conditions under which it must hereafter operate, such as the necessity of maintaining a salaried secretary, an office staff and permanent headquarters, it was essential to obtain a greater income. He believed that an increase in the dues from \$5 to \$7.50 would increase the revenue to \$5,000 or \$5,500, which he held to be sufficient, saying that if it should prove to be insufficient it would then be time enough to increase the dues and fees to \$10.

"I greatly regret to oppose Mr. Bowles," said Mr. Stevenson Taylor, "but the difference between \$7.50 and \$10 seems to be insignificant." Mr. Taylor added that the council had given the matter of increase to \$10 very thorough consideration before submitting it to vote of the members.

Others thought the amendment out of order as long as the question had already been submitted to poll. The amendment was defeated and the original motion carried. The added revenue, it is expected, will be sufficient to meet the necessary expenses of the society. Hitherto the work has been largely a labor of love but it has grown so extended as to necessitate financial remuneration.

President Griscom surrendered the chair to Mr. W. D. Forbes while the council submitted the following list of officers for the ensuing year:

President—Clement A. Griscom.

Secretary and treasurer—W. L. Capps.

Vice Presidents—Francis T. Bowles, Chas. H. Cramp, F. L. Fernald, Philip Hichborn, Chas. H. Loring, Geo. W. Melville,

Geo. W. Quintard, Irving M. Scott, Stevenson Taylor, Edwin A. Stevens.

Members and associate members of council—W. I. Babcock, W. L. Capps, French E. Chadwick, James E. Denton, Geo. W. Dickie, Wm. F. Durand, A. P. Niblack, Nathaniel G. Herreshoff, Ira N. Hollis, Wm. H. Jaques, John C. Kafer, Frank B. King, Frank E. Kirby, W. M. McFarland, Jacob W. Miller, Lewis Nixon, Cecil H. Peabody, Walter A. Post, Harrington Putnam, Horace See, E. Platt Stratton, David W. Taylor, Henry G. Morse, Geo. E. Weed.

Executive committee—Francis T. Bowles, Harrington Putnam, Stevenson Taylor, Louis Nixon, Edwin A. Stevens; ex-officio, Clement A. Griscom and W. L. Capps.

PRESIDENT GRISCOM'S ANNUAL ADDRESS.

Upon the mention of Mr. Griscom's name for re-election as president there was great applause. There was a further outburst as he regained the platform and thanked the members for the honor. President Griscom said:

"It is with feelings of especial appreciation that I make acknowledgment on this, our tenth anniversary, of your continued indulgence in selecting me to be your president. I have, on several previous occasions, remonstrated with you for persisting in selecting a comparative layman for this high office, but I have none the less been keenly sensible of the honor conferred by you, and beg to thank you again most earnestly for your marked appreciation of whatever I have been instrumental in doing in furtherance of the interests of a society whose objects are of such great national importance, and whose methods of disseminating knowledge are so purely unselfish.

"I have no inclination to keep you longer than is absolutely necessary from the consideration of the very interesting professional papers contributed to this year's meeting, but anniversaries inevitably invite retrospection, and the developments in ship building, both naval and commercial, have been so marked during the past decade that you will, I know, pardon a brief illusion to their more salient features. At the time of the foundation of this society in 1893, the American mercantile marine was still struggling against adverse conditions largely due to national apathy in all matters affecting our maritime prestige. It is true that the requirements of trade on our seacoast and the great lakes had stimulated the building of a large number of vessels of moderate tonnage, but the great bulk of the transatlantic, and even the transpacific, trade was under foreign flags, and it must still remain a matter for national regret and humiliation that such a small percentage of our foreign commerce, emanating upon our soil and controlled by our capital, is transported under our national flag. It is to be hoped that our commercial necessities and a quickened public sentiment may serve as potential influences until the mercantile marine of the United States may again attain that supremacy among the fleets of the world which was once the source of our greatest national pride.

"Much has been written by distinguished naval historians demonstrating beyond reasonable doubt the vital importance of sea power in controlling national destinies; and, although a nation's sea power finds its undoubted direct expression in the size of its battleship fleets, its potential force is quite as definitely expressed by the size of its merchant fleets—and history has frequently emphasized the truth of these almost axiomatic statements. Therefore, while we may view with pride the development of our naval strength during the past decade, let us not as a nation forget that the foundations of true naval strength are large merchant fleets, from which the *personnel* of our battleships can be recruited both in peace and war; and let us always bear in mind that whatever contributes to the aggrandizement of the mercantile marine, adds to our national dignity and directly increases the offensive power of the nation.

"The members of this society are too well aware of the technical developments in their profession for a layman to venture upon more than a mere allusion to them. One of the most noticeable phases of this development has been the increase in size of vessels of the navy and mercantile marine. Vessels which today create no expressions of surprise, only ten years ago would have been considered impracticable. Whether this marked increase in size is altogether judicious, time alone can determine, but it clearly demonstrates that whatever limitations there may be to size, both in battleships and ocean greyhounds, they are not imposed by the naval architect and the marine engineer.



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Members of the Society of Naval Architects and Marine Engineers Assembled at Camden, N. J.
PHOTOGRAPH TAKEN WHILE VISITING WORKS OF NEW YORK SHIP BUILDING CO.

Supplement to the Marine Review of Cleveland, Nov. 27, 1902.

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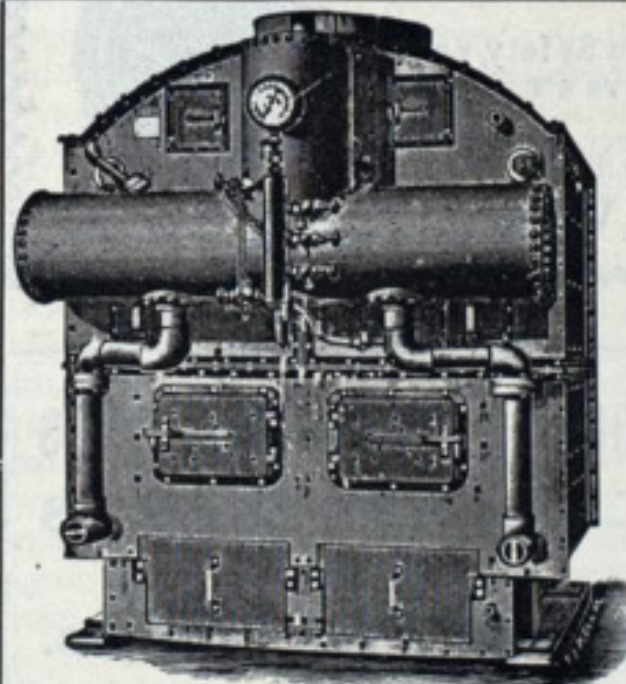
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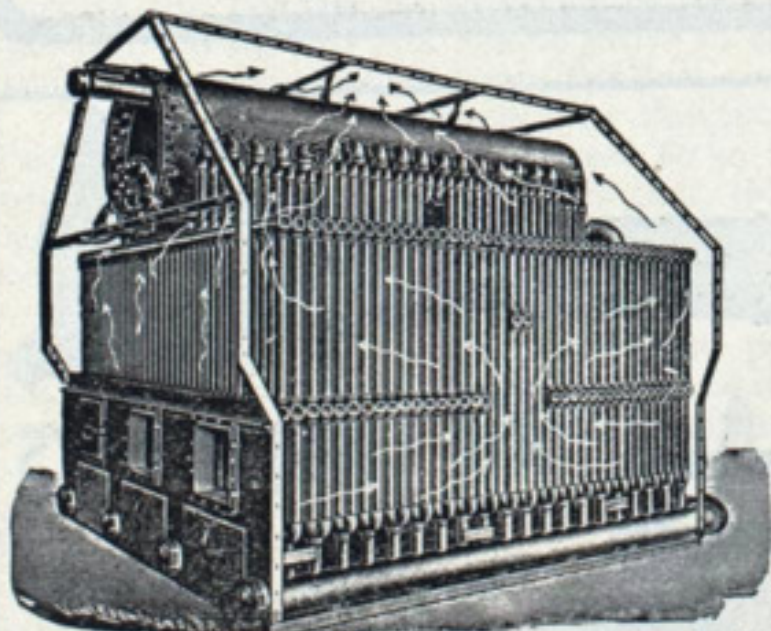
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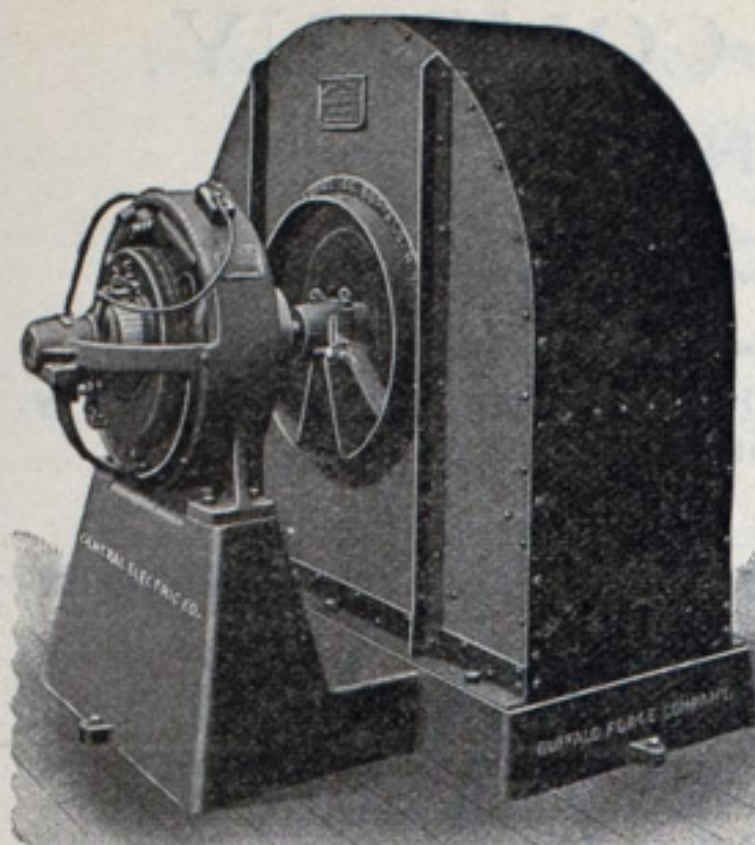
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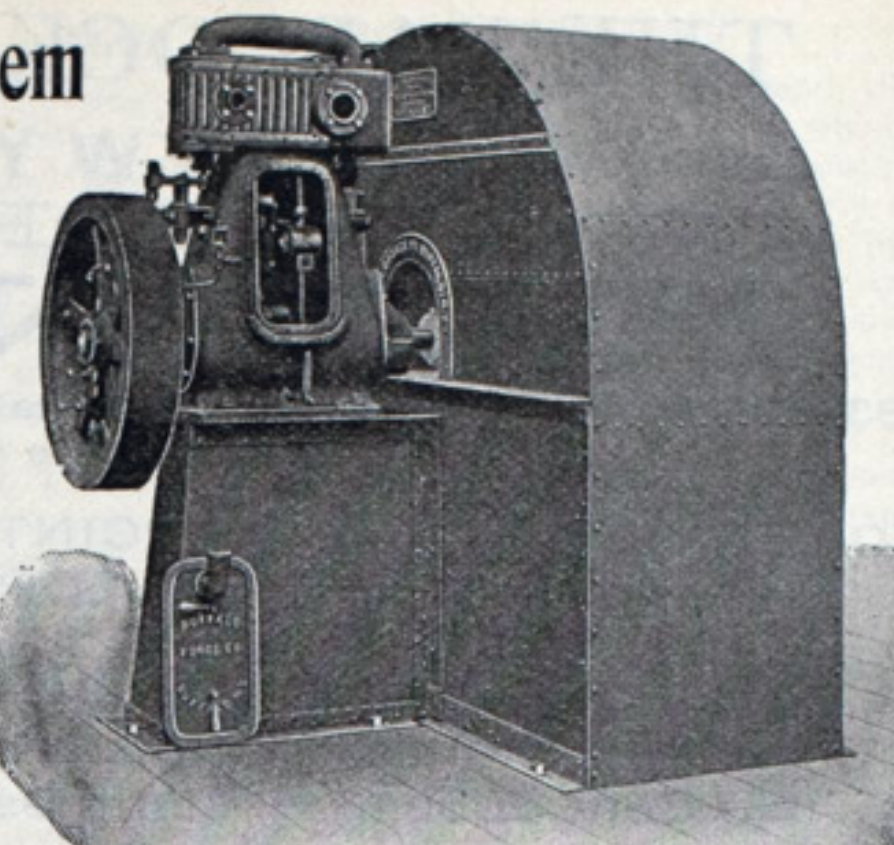
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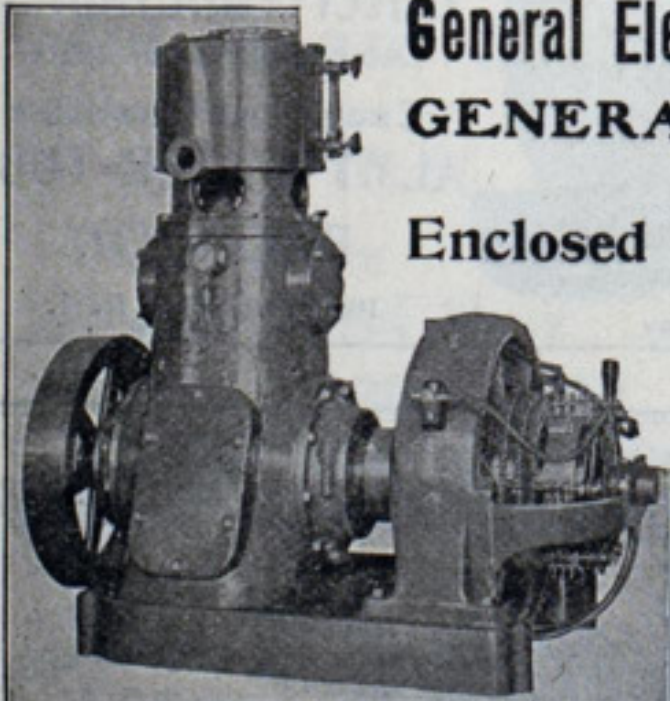


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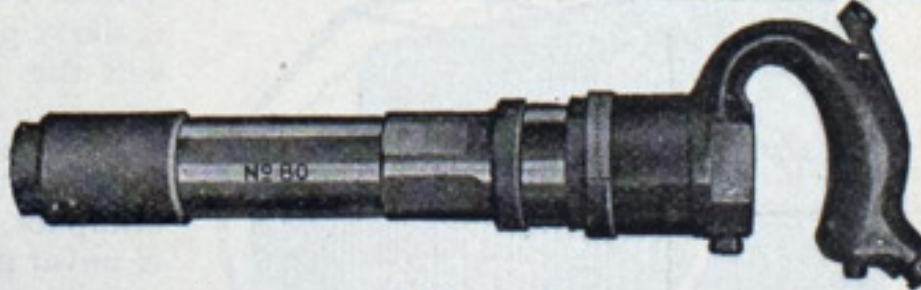
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AMERICAN NAVIGATION.

The United States once had a sufficient number of seagoing vessels of the best kind afloat to give us an enviable position in the maritime world; now other nations lead us, but the cause of the decline is a question open to argument. With a view to enlightening the public on this important subject William W. Bates, former United States commissioner of navigation, presents a valuable volume, with the title of "American Navigation". He writes a careful review of the beginning and development of the merchant marine and its decline, and suggests remedies for its restoration. His argument is not only vigorous, but interesting, and shows a thorough knowledge of his subject. He attacks sharply, even bitterly, all plans for maritime reciprocity treaties, subsidies or bounties of any kind, and defends the old policy that made our ships known everywhere—protection. In the last speech President McKinley delivered he said:

"We must encourage our merchant marine. We must have more ships. They must be under the American flag, built and manned and owned by Americans." In his letter accepting the nomination to his first term he expressed hearty approval of his party's national platform, which said: "The policy of discriminating duties in favor of our shipping, which prevailed in the early years of our history, should be again promptly adopted by congress and vigorously supported." This is the plan Capt. Bates supports to restore our prestige and supremacy on the seas. Once American ships did three-fourths of our transportation with Europe; in 1901 our production was 6.13 per cent. for export carriage and 11.99 for imports. If our early policy of discriminating tariff had been continued, our navigation would have kept pace with our commerce; but yielding to pressure from Great Britain a deviation began and decline followed. Today we have 80,000,000 people and yet cannot find sailors to man our navy in time of peace. An ample merchant marine would furnish them without any expense for training.

Congress began its work on shipping legislation April 8, 1709, when President Madison proposed resolutions to encourage carrying trade by discriminating tonnage duties. The old practice of carrying apprentices on ships, now long abandoned, is very properly defended as a means of obtaining American crews. In this connection Capt. Bates writes, in parentheses: "It will probably take another war to clean the country again of foreigners, so that an American marine shall once more have preference for employment." Great Britain has been charged for more than a century with being the most serious "breaker" for our navigation. Among her other impositions against us being the exorbitant "light charges" for the maintenance of her lighthouses,

which against a vessel of less than 300 tons was \$222 on a single voyage to London, and there were many others. The act of March 1, 1817, was one of the most important in the history of navigation and did much to strengthen our maritime power. The objects were to increase and protect employment of American vessels and American seamen, of American ship yards and American mechanics.

Our first treaty of amity and commerce was made with the Netherlands Oct. 8, 1782. In 1793, England warred with France; we were neutral. By violating neutral rights Great Britain seized or destroyed six hundred of our vessels. Then we made the Jay treaty—"to stay on land more, on the sea less." In 1828, protection was taken from ship owners, "while it was given to miners, manufacturers and other classes, not one more important to the country than navigators." Under this act all vessels were admitted free, a move "which increased opportunity for building up foreign navigation, gave us no advantage but caused the ruin of our marine." Capt. Bates gives a comprehensive review of conditions under maritime reciprocity, which, he says, makes it apparent that this policy must be repudiated before any remedy can be effective. "This policy makes us now a British dependency. . . . It has proved worse than useless to us, it is adverse and disastrous." To the administration's explanation of neglect to fix the promised discriminating duties that "treaties stand in the way," Mr. Bates declares "there is really nothing in the way but fear of displeasure of England."

The society of Lloyd's register of British and foreign shipping, which was organized in 1834, and which is commonly known as Lloyds, is described as a powerful enemy of American shipping, with much testimony to sustain the charge. A few pages are devoted to "rings," which control trade to and from England. The great Morgan merger, which has been given so much space in the newspapers, is dismissed with a page, the conclusion being that neither British loss nor American gain would be very extensive. "History of shipping legislation shows that we have but one way to encourage our general marine, and that is under the power to regulate commerce. . . . Our government has the power at any time to make a preference by law for the American vessels in American commerce." Senator Elkins, in 1896, introduced a bill on this line, but it was hung up in the committee and the Hanna-Payne bill reported. The latter's limited contract plan "stamps the bill as inexpedient and illusive." The bill was rejected and the Frye bill appeared. This measure, now pending in revised form, Mr. Bates condemns on the ground of its cost, which he considers sufficient. "Besides being unconstitutional, the subsidy principle is un-American from every point of view. . . . Subsidies and bounties cannot in their nature fill the place of regulations."

In closing, a measure to stimulate shipping is given, which the author believes would have the desired effect. Merchandise bears the brunt of discrimination, and vessels are affected only indirectly unless bringing goods from countries not their own. The volume is well arranged with index, and numerous illuminating tables. It is dedicated in memory of James Madison, "the friend of American ship building, and the able and fearless champion of American commerce and navigation."

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MISCELLANEOUS MATTERS.

The first section of the floating dry dock which started from Havana a while ago has reached Pensacola in safety.

A. J. Moxham, formerly president of the Lorain Steel Co. and later general manager of the Dominion Iron & Steel Co., Sydney, N. S., has settled at Wilmington, Del., where he has entered into the manufacture of powder.

The secretary of the navy has decided to issue orders for the reassembling of all the torpedo craft at Newport next summer for a series of maneuvers devoted entirely to these craft. It is expected that at least twenty vessels will be in the flotilla.

S. Parker Bremer, Boston, Mass., is to have a steamer built by the Gas Engine & Power Co. and Charles L. Seabury & Co., Morris Heights, N. Y., similar to the Vixen, built last spring for John D. Archbold. This steamer will be 110-ft. over all, 104-ft. on the water line, 14-ft. beam and 4 ft. 9 in. draught.

The contract for repairing the British tank steamer Tioga, which burst her intermediate and high-pressure cylinders while getting under way on Oct. 22, has been awarded to Bertelsen & Petersen of East Boston. Eight bids were submitted for making the necessary repairs, including three from New York parties. Bertelsen & Petersen's bid was the lowest, and by the terms of the contract the firm agreed to complete the work in sixty days.

It has been officially announced that the shares of the Atlantic Transport Co. will be exchanged for the new shares of the International Mercantile Marine Co. on Dec. 1. The owner of each share of the former will receive three shares of the preferred stock and one share of the common stock of the new company and \$15 in cash. The cash represents the adjustment for the dividend withheld from the stockholders of the Atlantic Transport Co. while the new company was in course of organization.

Admiral Dewey will hoist his flag Dec. 1 on the Mayflower, now at the Washington navy yard, and will sail the same day with an imposing staff direct for Culebra island, where he will exercise command over the combined squadrons during the winter exercises. The Admiral's plans have been completed, his staff selected, and the Mayflower made ready for her work, which will last probably three months. None of Admiral Dewey's present personal staff will be with him during the maneuvers, and instead he will be surrounded by a large number of officers composing the general board. No special instructions will be issued the admiral, but he will have wide latitude in determining what the fleet shall do and how much time is to be devoted to certain subjects. The general board has so completely outlined the work that the navy department does not regard specific instructions as necessary.

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English Royal Navy	-	-	-	-	-	-	-	-	745,900 "
Russian Imperial Navy	-	-	-	-	-	-	-	-	184,900 "
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Austrian Imperial Navy	-	-	-	-	-	-	-	-	32,900 "
Italian Royal Navy	-	-	-	-	-	-	-	-	13,500 "
Chilian Navy	-	-	-	-	-	-	-	-	26,500 "
Argentine Navy	-	-	-	-	-	-	-	-	13,000 "
The "Messageries Maritimes" Company	-	-	-	-	-	-	-	-	87,600 "
Chemins de fer de l'Ouest: (The French Western Railway Co.)	-	-	-	-	-	-	-	-	Steamships
plying between Dieppe and Newhaven	-	-	-	-	-	-	-	-	18,500 "
Total Horse Power of Boilers <u>in Use</u>	-	-	-	-	-	-	-	-	1,501,520

WORKS: Ateliers et Chantiers de l'Ermitage, at Saint-Denis (Seine), France.

TELEGRAPHIC ADDRESS: Belleville, Saint-Denis-Sur-Seine.

"The past decade has also witnessed marvelous development in turbine motors, submarine boats, wireless telegraphy, fuel-oil for ships, electric auxiliaries of all kinds, and other forms of application of power, all of which have had and will continue to exercise a most important influence on the future evolution of naval and mercantile fleets.

"While it is not my intention to burden you with statistics concerning the development of our naval and mercantile marine, the very marked development in our naval strength during the past ten years is worthy of special comment. At the time of the organization of this Society, only one first-class battleship had been launched, the *Indiana*, and it was not until more than two years later, on Nov. 20, 1895, that our first first-class battleship was commissioned for active service. There are now built or building nineteen battleships of the first class, and of these nine are in active service. There are now in course of construction for the navy ten battleships, eight armored cruisers, nine protected cruisers, four monitors, three gunboats, ten torpedo boat destroyers, six torpedo boats and seven submarine boats, of an aggregate displacement of 317,760 tons. Large as this may seem, it is very far from the final development which is necessary, in order that we may command our proper place among the nations of the world.

"The splendid achievements of our navy in the war with Spain proved the efficiency of this arm of our national defense, and justify its continued increase as a means, not only of national defense, but also national development, since it has been largely through the upbuilding of our navy that many industries have been developed to a degree of perfection which now permits us to compete on equal terms with the manufacturers of other countries. Any allusion to the recent achievements of our naval forces would be incomplete did it not include definite mention of one of our honored vice-presidents, Admiral Sampson, who has left us during the past year. To his professional skill and foresight, and to his thorough preparation of the fleet under his command, is largely due the brilliant successes of the naval campaign in the West Indies.

"Now, gentlemen, just a word in conclusion about our society. In the last ten years we have grown from a membership of little more than 400 to nearly 1,000. Thanks to the conservative administration of your executive committee, and the untiring and unselfish labors of your two secretaries, you have with small resources, accomplished great results. The society is, in every way, in a most prosperous condition, and the desire to fill its chief office is one eminently worthy to be entertained by those high professional attainments and successful achievements have brought distinction upon your membership.

"When I first accepted the honor of the presidency at your hands, I took it, not as a personal tribute, but rather as a recognition of the important interests over which I presided, and which were so intimately associated with your art. The time is now come, I believe, when another should be chosen to preside over your deliberations. This conviction on my part is in no sense the result of waning interest, you may be sure, since this society can always command my most earnest endeavor in its behalf, and will always retain my very best wishes for its success; it is due rather to the belief that the honors you have so generously conferred upon me during the past ten years should, in future, go to others. And so, fellow members, I request that you will consider these remarks my valedictory, and at or before the expiration of ten years of my association with you as president, place at the head of our society some one of our membership whose distinguished services and professional attainments will grace an office which is in every way worthy of our highest aspirations."

NEW MEMBERS AND ASSOCIATES.

Following are the names and addresses of new members, associates and juniors elected at the meeting:

New members—T. E. Artis, Bath Iron Works, Bath, Me.; G. H. Barrus, mechanical engineer, 12 Pemberton square, Boston; F. W. Belknap, Gardner & Cox, 1 Broadway, New York; H. A. Evans, assistant naval constructor, navy yard, Norfolk, Va.; D. A. Hector, Fore River Ship & Engine Co., Quincy, Mass.; F. M. Hoyt, Greenport Basin & Construction Co., Greenport, N. Y.; William Hovgaard, Massachusetts Institute of Technology, Boston; James McKinley, Union Iron Works, San Francisco; Al. J. Mickley, department of docks and ferries, New York City; Edmund Mills, marine department, the Babcock & Wilcox Co., Bayonne, N. J.; L. J. Nilson, the Nilson Yacht Building Co., Ferry Bar, Baltimore, Md.; Charles O'Neil, chief of the navy bureau of ordnance, Washington, D. C.; T. D. Pitts, Tams, Lemoine & Crane, 52 Pine street, New York; Charles B. Rowland, the Continental Iron Works, Brooklyn; Antonio J. d'Althouguia, Portuguese navy, 13 Rua da Paz, Lisbon, Portugal; Charles Schofield, Eastern Shipbuilding Co., New London, Conn.; Capt. J. A. B. Smith, department of steam engineering, navy yard, Brooklyn, N. Y.; John A. Stevens, Merrimack Mfg. Co., Lowell, Mass.; Frank N. Tandy, naval designer, 31 State street, Boston; Philip M. Young, engine department, New York Ship Building Co., Camden, N. J.; Rudolph Zirpel, United States lighthouse service, 525 Third street, N. E., Washington; Geo. H. Eimert, A. B. Wallen, A. L. Busch, James F. Waddington, Edward Smith, Lieut. Albert

Moritz, Rear Admiral P. C. Asserson, Archibald Johnson, P. F. Walker; Geo. Q. Palmer, manager Quintard Iron Works, New York; E. W. Hyde, president Bath Iron Works; Christian Blom, Norwegian navy; R. H. Allen, Fore River Ship & Engine Co.; Lieut Com'dr W. Ali, Turkish navy, care Cramp's ship yard Lieut Com'dr Sabri, Turkish navy, care Cramp's ship yard.

Promoted from associate to member—D. H. Cox, assistant naval constructor, Washington, D. C.; C. J. Dougherty, Wm. Cramp & Sons Co., Philadelphia; W. F. Powers, Moran Brothers Co., Seattle, Wash.; R. H. M. Robinson, assistant naval constructor, navy yard, New York; Edson B. Schock, naval architect, 17 State street, New York; J. W. L. Waters, American Bureau of Shipping, 66 Beaver street, New York; Walter A. Post, Newport News, Va.

New associates—A. E. Boric, Bethlehem Steel Co., South Bethlehem, Pa.; P. B. Brill, Wm. Cramp & Sons Co., Philadelphia; D. W. Dickie, Moran Brothers Co., Seattle, Wash.; E. P. Field, 53 West Forty-sixth street, New York; Gen. Eugene Griffin, General Electric Co., 44 Broad street, New York; George McQuilkin, jr., navy bureau of construction and repairs, Bath, Me.; E. M. McTharin, Bethlehem Steel Co., South Bethlehem, Pa.; E. A. Perkins, naval architect and engineer, Maritime building, New York; M. B. Pollock, U. S. S. *Indiana*; R. A. Robbins, Manhattan Supply Co., New York; H. B. Shields, office of superintending naval constructor, Wm. Cramps & Sons Co., Philadelphia; H. H. Smith, marine department Thresher Electric Co., Dayton, O.; H. S. Snyder, Bethlehem Steel Co., South Bethlehem, Pa.; H. C. Watts, International Smokeless Powder Co., Philadelphia; Clark H. Woodward, Navy Department, Washington; Wm. De Wolf Dimock, R. J. Donovan, Henry Rice, John J. Amory; E. B. Frost, Holland Torpedo Boat Co.; T. C. Hirsch, New York Kerosene Oil Co.; A. J. Jupp, the Lunkenheimer Co.; E. F. Able, Crescent Ship Yard, Elizabeth, N. J.; C. J. Langrell, Harlan & Hollingsworth Co., Wilmington, Del.; John E. Bailey, assistant naval constructor, Washington, D. C.; John E. Meek, H. W. Johns Co., New York; R. G. Bickford, admiralty lawyer, Newport News, Va.

Promoted from junior membership to membership—W. R. Ballard, Moran Brothers Co., Seattle, Wash.; H. N. Whittelsey, Marine Construction & Dry Dock Co., Mariners Harbor, New York; M. M. Whitaker, Canada Launch Works, Toronto, Can.; Dean Clark; Charles P. Paulding, 128 W. Eleventh, New York.

LIST OF NEW JUNIORS.

New juniors—H. B. Appleby, navy yard, Brooklyn, N. Y.; M. M. Bordon, New York Ship Building Co., Camden, N. J.; Ross W. Bragg, New York Ship Building Co., Camden, N. J.; F. E. Craig, Neafie & Levy Co., Philadelphia; F. H. Crane, Theo. Crane's Sons Dry Dock & Ship Yard, Erie Basin, Brooklyn, N. Y.; O. B. Evans, New York Ship Building Co., Camden, N. J.; W. M. Finkenaur, Wm. Cramp & Sons Co., Philadelphia; H. L. Grant, New York Ship Building Co., Camden, N. J.; Henry J. Hack, New York Ship Building Co., Camden, N. J.; Jay D. Hammond, Townsend & Downey Co., Shooters Island, New York; L. W. Hesselman, American Tin Plate Co., 907 Battery Park building, New York; L. F. Hewins, Navy Yard, Washington; J. H. Holt, Midvale Steel Co., Philadelphia; James W. Hussey, New York Ship Building Co., Camden, N. J.; A. C. Jennings, Eastern Ship Building Co., New London, Conn.; M. C. Kindlund, Burlee Dry Dock Co., Port Richmond, Staten Island, New York; L. W. Krout, office of naval constructor, Harlan & Hollingsworth Co., Wilmington, Del.; C. L. Loos, jr., American Ship Building Co., Cleveland, O.; A. E. Luders, Tams, Lemoine & Crane, 52 Pine street, New York; Wm. MacHattie, Marine Engine & Machine Co., Harrison, N. J.; C. L. Morrison, Wm. R. Trigg Co., Richmond, Va.; George Moses Purver, American Bridge Co., 7 West Twenty-second street, N. Y.; W. M. Rice, John N. Robins Co., Erie Basin, Brooklyn, N. Y.; J. A. Ross, jr., office of naval constructor, Moran Brothers Co., Seattle, Wash.; Paul A. Suwald, New York Ship Building Co., Camden, N. J.; Perry K. Thurston, Neafie & Levy Co., Philadelphia; Charles C. Turner, George Lawley & Sons Corporation, South Boston, Mass.; William Uzelmeier, New York Ship Building Co., Camden, N. J.; W. W. Wassilieff, L. Powers & Co., Philadelphia; John M. Watts, New York Ship Building Co., Camden, N. J.; Frank B. Whitaker, naval constructor's office, Newport News ship yard, Newport News, Va.; Wm. W. White, Wm. Cramp & Sons Co., Philadelphia; Alex. E. Zetterman, George Lawley & Sons Corporation, South Boston, Mass.; Clyde Yeomans, construction and repair department, navy yard, New York; Lee R. Stewart, New York Ship Building Co., Camden, N. Y.; John F. Sullivan, navy yard, New York; E. B. Osborn, Croton-on-Hudson, N. Y.; Thos. E. Webb, jr., navy yard, New York; H. C. Towle, A. B. Tappan, J. S. Potter, H. W. Patterson, J. G. Bradley, Edw. Lanhan, J. G. Purdy, Ernest Fils, Preston S. Stone, Clarence H. Harden, L. H. Cummings, Henry B. Spear, Rowland Dimelow, Les. Weir Brownrigg; David Hayes, Old Dominion Steamship Co., New York; A. M. Cregier, Columbia University, New York; R. W. Berliner, Quintard Iron Works, New York; Frank N. Horton, Fore River Ship & Engine Co., Quincy, Mass.; John Haupt, 198 Bedford Park, New York; Chas. F. O'Donnell, navy yard, Brooklyn.

A LIST OF MEMBERS AND OTHERS ATTENDING THE MEETING.

Following is a list of members of the society who were present at the sessions for the reading of papers, who attended the banquet, or who made the trip to the works of the New York Ship Building Co.:

J. R. Andrews,	Geo. N. Gardiner, Jr.,	M. Pfatischer,
E. F. Able,	P. T. Garven,	E. R. Pommer,
John J. Amory,	Naval Constructor W.	C. P. Paulding,
Rear Admiral C. As-	G. Groesbeck.	F. E. Pratt,
erson,		H. F. J. Porter,
H. L. Aldrich,	Charles H. Haswell,	Prof. C. H. Peabody,
D. Almy,	Wm. H. Harrison,	James G. Purdy,
C. F. H. Almy,	F. L. Hoyt,	L. R. Pomeroy,
A. E. Aeby,	F. C. Hirsch,	A. Pretchoff,
Lieut. Ali of Turkish	J. Hunt Holt,	John Platt,
navy.	J. A. Hargan,	N. F. Palmer,
	Chas. H. Hughes,	Howard Pusey.
Rear Admiral F. T.	Prof. W. Hovgaard,	
Bowles,	W. D. Hoxie,	
Chief Carpenter J. W.	Myron T. Herrick,	E. P. Robinson,
Burnham, U.S.N.,	Naval Constructor Jno.	D. C. Reed,
C. S. Butts,	F. Hanscom,	H. S. Reed,
Wm. L. Bulkley,	F. Hand,	R. A. Robbins,
Naval Constructor W.	Richard P. Hart,	Asst. Naval Constructor
J. Baxter,	W. H. Huhen,	R. H. M. Robinson,
Prof. A. H. Bull,	Warren E. Hill,	H. B. Roelker,
Wm. Boyd,	Edward Hill,	Alfred H. Raynal,
J. T. Boyd,	James J. Hill,	Prof. Chas. B. Richards,
Geo. H. Bates,	Gustav Hillman,	T. F. Rowland, Sr.,
Naval Constructor Lloyd	E. W. Hyde,	Chas. B. Rowland,
Bankson,	H. C. Higgins,	T. F. Rowland, Jr.,
Daniel Bailey,	R. S. Haight,	Wm. Rowland,
W. H. Bailey,	Naval Constructor J. B.	Wm. R. Roads,
F. S. Brinton,	Hoover,	H. T. Rowley,
J. Barre,	T. S. Hall,	Geo. Rollet,
W. B. Beckley,	John Haug.	Chas. E. Ross.
F. W. Belknap,		
Civil Engineer Bellin-	A. J. Julp,	Alex. R. Smith,
ger, U.S.N.,	W. H. Jaques,	A. G. Smith,
Les Weir Browning,	H. Janson,	Com'dr. J. A. B. Smith,
J. F. Bruton,	Julius Jonson,	Carroll S. Smith,
Wm. Burlingham,	S. S. Jordan.	S. K. Smith,
C. A. Blomberg,		H. H. Smith,
J. Bauchli,	John C. Kafer,	Naval Constructor H.
Geo. C. Bowers,	W. E. Kimball,	T. Smith,
W. I. Babcock,	W. D. Kearfott,	Wm. P. Smith,
W. Binley,	Otto B. Keller,	Naval Constructor S.
Lieut. Com'dr. T. Burg-	J. Katzenstein,	F. Smith,
dorff,	M. Katzenstein,	T. J. Shaw,
Arthur L. Busch,	L. Katzenstein,	James Swan,
John M. Blankenship,	J. W. Kellogg,	F. H. Stillman,
F. O. Blackwell,	J. Kellogg,	E. A. Stillman,
Geo. A. Barress,	M. G. Kinlund,	Hon. Frederick Storm,
Chas. H. Buckelew,	F. B. King.	F. Schoonmaker,
J. H. Blanchard,		H. A. Swanton,
H. E. Boucher.	Com'dr. Chas. H. Lor-	Prof. A. H. Sabin,
	ing,	R. E. Sabin,
Edwin S. Cramp,	P. Loventhal,	S. W. Stanton,
Capt. A. L. Comacho,	A. J. Lancaster,	Capt. E. H. Scribner,
Mexican navy,	V. F. Lassoe,	Lawrence Spear,
H. Christopherson,	Robert S. Lewis,	B. C. Stuart,
H. R. Curwen,	W. S. Leland,	Capt. W. G. Shackford,
Com'dr. A. B. Canaga,	O. B. Libby,	S. A. Savage,
Naval Constructor D.	John Loyd,	T. B. Southard,
H. Cox,	Chas. Longstreth,	H. Staph,
C. G. Curtis,	L. D. Lovekin,	W. P. Stephens,
F. H. Crane,	A. C. Leitch,	H. B. Shields,
Naval Constructor W.	F. P. Lewis,	Perry S. Stone,
L. Capps,	M. Lewisham,	J. F. Sullivan,
F. H. Cross,	J. J. Lynn,	Lieut. Sabre of Turkish
Nicholas Cushing,	Theodore Lucas.	navy.
Robert Curr,		Col. E. A. Stevens,
Geo. Clarke,	E. R. Mead,	E. Platt Stratton,
M. S. Chase,	A. M. Main,	Sinclair Stuart,
Geo. C. Cook.	D. G. Moore,	Prof. H. C. Sadler,
	A. B. Moore,	Horace See.
W. DeW. Dimock,	M. F. Moore,	
John Dallett,	Henry B. Moore,	
W. A. Dobson,	A. J. Mickley,	A. A. Thresher,
P. J. Donnelly,	W. W. Meek,	Prof. C. C. Thomas,
John Drew,	J. A. Meek,	Wm. L. Tobey,
Prof. Jas. E. Denton,	J. W. McCormack,	Stevenson Taylor,
H. L. Des Anges,	H. L. Meeker,	James A. Thomson,
A. C. Dreyfos,	C. McGowan,	H. H. Thayer,
F. L. DuBosque,	Wm. McIntosh,	Frank H. Taylor.
Wm. H. Deming,	R. C. Monteagle,	
Richard Deming,	A. Masters,	J. A. Ubsdell, Jr.
Hugh Dougherty,	Col. E. K. McClure,	
E. S. Denise,	Henry A. Magoun,	W. E. Volz,
W. H. Dimock,	J. L. McVicker,	Naval Constructor W.
Prof. Wm. F. Durand,	H. C. Meyer, Jr.,	H. Varney,
W. D. Dickey.	T. Mathewson,	John D. VanBuren.
	James McGulre,	
Chas. G. Eckstein,	Chief Engineer E. A.	
Charles Englis,	Magee, U.S.N.,	A. G. Wilson,
E. H. Ewertz,	Geo. W. Magee,	T. A. Watson,
Rame Ewell,	Prof. A. J. Maclean,	Wm. E. Winant,
J. W. Eaton,	S. D. McComb,	James G. Winship,
Rear Admiral A. C.	Capt. Thos. I. Miller,	F. C. Whitehouse,
Engard,	Spencer Miller,	Geo. E. Weed,
Jarvis B. Edson,	P. H. McGlehan,	C. E. Wells,
J. G. Emmons,	C. D. Mosher,	Asst. Naval Constructor
H. P. Elwell,	Chas. H. Mallory,	H. Williams,
J. P. Elliott,	C. D. Mabury,	A. D. Woods,
L. Endeletz,	C. J. Menetz,	Geo. P. Wilson,
	Chas. H. Martin,	W. C. Williamson,
Wm. H. Fletcher,	Chas. W. Martin,	Com'dr. Wm. H. White,
A. Fletcher, Sr.,	John M. Mulrooney.	P. A. B. Widener,
A. Fletcher, Jr.,		Chief Engineer B. F.
Naval Constructor F. L.		Wood, U.S.N.,
Fernald,		C. M. Wales,
B. G. Fernald,	Lewis Nixon,	C. Ward,
G. R. Ferguson,	L. Nilson,	B. S. Ward,
E. H. Foster,	J. L. Nelson,	Wm. H. Williams, Jr.,
Com'dr. Frye,	John Nolan,	F. M. Wheeler,
D. E. Ford,	R. L. Newman,	G. W. West,
W. A. Fairburn,	Chas. A. North,	Geo. H. Waters,
M. Ferguson,	W. W. Nixon,	R. K. Wright,
W. D. Forbes.	Naval Constructor D.	W. R. C. Wood,
	C. Nutting,	Capt. S. Walter,
	Geo. L. Norton,	J. M. Wilson,
		T. C. Webb,
		H. C. Watts,
		W. W. Wasseleff.
Clement A. Griscom,	B. F. O'Connor,	
W. Gardner,		C. Yeomans,
Naval Constructor H.	S. Putman,	Wm. J. J. Young.
G. Gillmor,	E. A. Perrin,	
Geo. N. Gardiner,	J. V. Patterson,	

DR. HENRY SMITH PRITCHETT.

Dr Henry Smith Pritchett is a Missourian by birth and is the son of Prof. C. W. Pritchett, director of the Morrison astronomical observatory at Glasgow. Dr. Pritchett was trained an astronomer under Prof. Asaph Hall at the naval observatory at Washington and by study at the university at Munich where he obtained his doctor's degree. Appointed assistant professor of mathematics and astronomy in the Washington university of St. Louis in 1881, he remained on the faculty of that institution for sixteen years, leading, meanwhile, the Transit of Venus expedition in 1882 to New Zealand, presiding over the St. Louis Academy of Sciences and publishing many papers on astronomical and geodetic topics. Called in 1897 to be the head of the United States coast and geodetic survey, Dr. Pritchett made so admirable a record in that important administrative position that the corporation of the Massachusetts Institute of Technology sought him as its president. He was chosen for that office in October, 1900.



Dr. Henry Smith Pritchett.

TECHNICAL TRAINING FOR SHIP BUILDERS.

The business of reading and discussing the program of papers now became the order of the day. In the absence of President Pritchett of the Massachusetts Institute of Technology, Secretary Capps read Mr. Pritchett's paper upon the subject "Technical Training for Ship Builders." The paper follows:

A modern steamship, whether built for trade or for war, is the embodiment of all the knowledge and skill that has been developed by the science and art of our modern world. The most profound investigations of mathematicians, physicists and chemists, the most refined methods of metallurgists and metal workers, the latest developments of engineering and electricity, and the best skill of a score of trades, have contributed to her design and construction. Recent years have shown rapid changes and great increase in size and complication, but the history of ship building shows a natural growth without any discontinuity, from the time when ship builders cut their own timber, fashioned it on the ground and shaped the ship to suit their ideas and traditions. The master ship builder measured off the length of the keel, set up stem and stern-post and middle frame, sprung the ribbands and battens, and the ship grew to match the idea in his mind without the intermediary of drawing or calculation. Other tradesmen, such as the blacksmith and rope maker, might aid, and subsidiary trades might grow up like caulking and rigging, but the ship carpenter was the ship builder; when he found it convenient he fashioned a model with his own hands, and from it drew the lines to which the frames were hewn. The great fleet of wooden schooners that steam and steel cannot drive from the sea, were, and are, built in this way.

With the advent of steam power the ship builder, perforce, entered into partnership with the engine builder, the province of each being marked off by the material in which he worked. Now that ships are built of steel the line of demarkation is maintained, giving naval architecture and marine engineering, terms which fail to cover the whole field and which are not exact complements of each other. A curious survival of the original demarkation is the assignment of the design of the screw propeller to marine engineering, while the determination of the power required for propulsion is made by the naval architect, who cannot make an intelligent investigation of his problem without knowing what propeller is to be used. Again, there is the distinction between the engine bed and engine seating, though they not only join, but have a tendency to coalesce. Meanwhile the ship carpenter has sunk to the level of a subsidiary tradesman and ranks with the ship joiner.

The occasion for retelling this story, so well known to us all, is to set forth clearly the fact that there does not appear to be a successor to the master ship builder. And yet ships are built and the numerous trades and professions are harmonized and somebody carries the responsibility for the construction. The responsibility may be divided among the superintendent, the naval constructor, and the marine engineer, but unless one of them has the final decision, they must one or all be overridden by a superior, and the one who finally decides stands in the place of the master ship builder.

There is no need today to dwell upon the necessity of technical training for the naval architect and the marine engineer, and it may be admitted that the superintendent will be none the worse for such a training. There may be differences of opinion as to details, but there is not likely to be much dissent from the opinion that a part of the technical training of these men can be most economically obtained in some sort of a technical school. Let it be admitted that all these and the master ship builder (if there be one) shall be ranked as ship builders, together with their assistants and the young men who are growing up in the business, and let us see if there can be found a common body of technical

training proper for all ship builders, and such as can be given in a technical school or college. At the Massachusetts Institute of Technology those interested in the teaching of naval architecture and ship design have, during the past three years, tried to attack this problem specifically, not only in the interest of the course in naval architecture already established at the institute, but also for the further reason that the institute has been selected by the United States navy department as the place of instruction for officers ultimately to be assigned to the corps of naval constructors. In preparation for this instruction the whole question of technical training for builders of ships—whether merchant ships or ships of war—has been gone over afresh. The following statements represent the conclusions to which those in direct charge of this work at the institute have been led, as stated by the head of the department of naval architecture, and, although to rehearse this is to retell a story already told, it may nevertheless have interest for the members of this association as a concrete effort to deal with the problem of the technical training of ship builders.

BULK OF TECHNICAL PREPARATION MAY BE COMMON.

A study of the training fitting for any branch of ship building will show that the bulk of the technical preparation may be in common, whatever divergence may appear necessary to provide for specialties. The basis of such a course for a naval architect or a marine engineer, will be mathematics, chemistry and physics, just as for any engineer, using that term to designate any who apply the resources of science and art to the building of large and important structures. Both will need substantially the same training in applied mechanics and strength of materials, combined with work in the laboratory, where the student will, in addition to learning how tests are made, gain some appreciation of the nature of the materials, and will learn how to interpret the original work of experimenters; he may afterwards safely use abstracts of results and engineers' handbooks which shall no longer be to him a record of dry statistics but a storehouse of living facts which he can trace back to their origin at will. Another way of obtaining knowledge of materials is by shop work. One who has learned how to do good work in wood and iron will ever after appreciate good work when he sees it. The general educational value is even more important, for he who has learned decision from forging and accuracy from machine-tool work, has gained more in character than in knowledge. The elements of shop work can be most effectively taught in the mechanical laboratories of a technical school; the naval architect and the marine engineer will need to gain experience in the yard or in the engine shop (or in both), where he will learn much that is more important than methods of work; but such experience, whether taken together with a technical course or after it, is not properly a part of such a course; it is part of the training that comes with the business in which a live man never ceases to learn.

Let us add to the common stock descriptive geometry and mechanical drawing. The importance of proper fundamental training in these subjects is often underestimated, for the reason that a good draughtsman is seldom conscious that he is using the principles of descriptive geometry; he simply draws what he wishes to represent and thinks more of the thing than of the drawing. This is as it should be, but all teachers know the distress of a student who takes up both descriptive geometry and mechanism at the same time, and to whom a diagram or a drawing is only a strange assembly of lines and curves. And since both naval architect and marine engineer have to do with machinery, their training must include mechanism and dynamics of machines.

Now comes the question of steam engineering. The marine engineer must, clearly, have all he can get, and if the naval architect is to understand his coadjutor he must know so nearly as much as to justify his taking the rest. This appears, in any event, to be the view of the American schools of naval architecture, and in this they have the support of the Ecole du Genie Maritime at Paris. Having expressed the idea that the naval architect, the marine engineer, and the superintendent should all be ship-builders in the broadest sense, consistency requires us to accept the conclusion that the naval architect should, in his turn, have a good training in marine engineering.

DIVERSITY OF SUBJECTS ADDS VALUE.

Nothing has been said heretofore as to language, literature and other studies which, in a technical school, are considered to be non-professional. There are two sides to this question. In the first place, a student who has worked as long as is profitable on mathematical and scientific subjects may still continue to work on non-scientific subjects; in fact, such a diversity of subjects has a direct value in preventing him from becoming stale. Again, a technical man, if he is not to be a narrow drudge, must know something besides "shop," and be able to meet other educated men on common ground; and this is clearly recognized by our technical schools, and such provision made as they deem possible to meet this need. Most important of all, the technical man must be able to express himself clearly and effectively in his own language. The study of English and some contact with the best works of English literature is at once a part of the technical equipment and the most real source of a broad culture. A reading knowledge of foreign languages is likewise necessary.

Let us pause a moment to measure the quantity of work thus laid upon the student. Leaving aside steam engineering, marine

engineering and naval architecture, an examination of the curriculum of any technical school will show that the studies already mentioned consume three-fourths of the entire four years assigned. Had we extended our inquiry and included mechanical and electrical engineering, much the same result would have been reached; and no other result could be expected, as all construction and engineering rests upon the same basis, the divergences, however important they may be, appearing at the top. It is idle to discuss whether a building can best spare its roof or its foundation; it must have both, and it need not surprise us that the foundation should be the heavier. The regular courses of nearly all American technical colleges are of four years' duration, it having been found that, taking young men as they come to these institutions from the fitting schools, this period suffices for such a training as enables them to do successful work in their professions. Courses for naval architects are comparatively recent, but graduates from such courses have had the same experience. In other words, it is the opinion of those in charge of these courses in the Massachusetts Institute of Technology that a successful foundation of training in naval architecture and marine engineering can be attained in four years. They go further, and express the opinion that for the majority of young men it is preferable to complete their schooling in four years, and to gain the remainder of their education in actual practice. For those who wish to widen their theoretical training by the addition of courses in electricity or other subjects, graduate courses are proposed. Following are quotations from the general statement of the courses and the results attained from them as prepared by those in charge of this instruction in the institute:

"The lectures on naval architecture may well begin at the middle of the four years' course, at which time students will be sufficiently advanced in mathematics and physics to take up their specialty to advantage; possibly it may be well to begin with descriptive work in the second year. In any case the student should begin this work as early as possible; that his enthusiasm may be enlisted, and that he may learn to work hard for the pleasure of it; and when the work is once begun it should be continuous and cumulative. As for the special work of naval architecture there is probably but little chance for difference of opinion. In a man's specialty he should know all the theory he can master, not only because he may suddenly find himself in need of even that part which he has previously considered of no practical value, but rather that he may have the quiet confidence which comes from possession; he will not then find himself tempted to belittle or to overestimate any influence merely because it is unfamiliar. Fortunate is it that our American technical colleges have so consolidated the general body of engineering instruction that the professor of naval architecture may confidently count on his student's ability to turn that instruction, with the aid of but little special instruction, to the problems that arise in his specialty, thus affording more time for the problems peculiar to the specialty and keeping them clear and distinct.

THE LECTURES IN NAVAL ARCHITECTURE.

"For the sake of completeness the list of subjects covered by the lectures in naval architecture may be briefly given. Naturally the lectures begin with descriptions of methods of building ships of wood and of steel. In connection with this will be made visits to ship yards, and it is of the greatest importance that the student shall, throughout his course, either with an instructor, or by himself, visit yards and inspect ships in service and under construction. The officers of the institute find themselves under great obligations, in this regard, to the president of the Fore River Ship & Engine Co., who has so kindly placed the facilities of their great works at the service of its students.

"The theory of the properties of ships may be divided into two parts, statics and dynamics; the first deals with form, displacement, stability, and strength; the second with waves, rolling, resistance and propulsion. The first part is mainly mathematical, and can be presented in a certain and definite manner. The second part, various and form and nature, is incomplete in many places, and exists largely in the form of original memoirs. Much of it must be given in its incomplete condition, and this adds to the difficulty of both the student and instructor. Calculation of displacement is soon taught, so far as principles are concerned; the actual work is tedious and laborious, and while the student can and should gain fair facility in his work, he can become an expert ship computer by long practice which cannot be given and does not belong in a course of instruction. He should have free use of mechanical integrators and other labor saving devices, not only that he should become familiar with them, but because work that is done briefly distracts attention less from principles. In the treatment of stability and of problems depending on stability, a combination can be made of the methods of English and French writers, securing the directness of the practical English methods and the elegance and completeness of the French investigations. Of the several methods and devices of determining stability, only a few perhaps three, need attention; the method of cross-curves, Barnes' method, and for longitudinal inclinations, Bonjean's curves. In connection with stability, attention will be given to adding weights, flooding compartments, grounding, docking and launching. Instruction in drawing may well begin with drawing a set of lines from dimensions that are nearly fair, for the students must first learn what fair lines are and how to draw them. Computation of displacement by the

displacement sheet from these lines may well follow. The next problem should be a yacht design, because it requires lines that are radically different from those of a steamer, which will naturally be chosen for the first set, and the student's enthusiasm is enlisted and may be carried over into his design of a steamship.

DESIGNING A SMALL STEAMSHIP.

"By this time it is possible to start the class in the design of a steamship of moderate size; large enough to bring in all the problems of merchant ship design, and not too complicated to be grasped by a novice. Our experience is that each man should design and compute his own ship, and that the work may be so abbreviated that this is possible without omitting any essential work of the design. The computation will begin with a direct determination of the approximate dimensions for a specific purpose, which are afterwards to be checked by working out the displacement, resistance and power; it will include determination of weight, center of gravity, stability and strength, and will be concluded by computations for launching. The students will learn how to use rules and tables for scantling, and should write up specifications. In order that the student's design may go forward without delay and may have real educational value, the instructor should have on hand a large number of designs of the proper sort all worked up and tabulated for convenient reference, by which he can keep in touch with the student's work and direct and advise without hampering; at first the student may be guided till he begins to apprehend his problem, then he should be forced to decide and act for himself; the design should be good and practical, otherwise the educational value is sacrificed, but the finished perfection of a mature designer is not to be expected. It is well that the student should be made to realize that he is learning how to work at ship designing, and not take himself or his work too seriously.

"Returning to the theoretical work: That which has been called dynamics will include a study of waves, of rolling, of apparent weights as affected by waves and by rolling, and of resistance and propulsion by steam and under sail, together with a discussion of steering and maneuvering. This part of the theory so briefly summed up, is at once the most difficult and the most interesting. Methods should be as simple and direct as possible, avoiding excursions into what is yet largely hypothetical, but not shrinking from investigations which are intricate enough to tax the student's mathematical training when occasion may demand. In the course there should be given lectures on heating, ventilation and drainage, with what application there may be to design. It is well to give brief instruction in compass adjustment, for the ship designer should have in mind the location of the compass, and the naval architect may be called upon for anything if he once shows that he is a handy man. Finally, though not at all a part of naval architecture, it is well that the naval architect should know how to use a transit and level when occasion demands. Students should be urged to work in ship yards and engine shops in vacations, and fortunately a number of ship builders are generous in granting opportunity for such work. Mould loft work can be taught as vacation work in the drawing room if other opportunity is not found.

METHODS ADVOCATED ARE FUNDAMENTAL.

"Thus far attention has been giving to training for merchant work, though the methods advocated are fundamental and applicable to all kinds of ship building. Students who desire to make a study of warship design should take a graduate year after finishing the regular four years' course, or should plan for a five years' course from the beginning. To the theoretical work already outlined should be added courses of lectures on special forms of construction used on warships, on armor and armament, on submarine boats and automobile torpedoes. With another year at command, the student should be able to give considerable attention to electricity, which plays so important a part in modern war ships. Though entirely distinct from any course offered for civilians, it may be interesting to look at the course for naval constructors now offered by the Massachusetts Institute of Technology, and it may be useful as a guide in developing such graduate courses of war ship design as have been mentioned.

"The course of study, upon the completion of which the degree of master of science is conferred, was laid out with the advice of the bureau of construction and repair of the navy department, and seeks to add to the training already obtained at the naval academy, those subjects which are peculiar to naval architecture, and to extend and round out that training in such a manner as will best enable a naval constructor to meet the varied and exacting demands of his official position. The course includes all the theoretical instruction in naval architecture of the regular four years' course, to which is added another years' work which has special reference to the military requirements of naval vessels. Other subjects selected from the regular course are marine engineering, steam engineering and applied mechanics; the course is broadened and strengthened by courses in sanitation, heating and ventilation, foundations, metallurgy and metallography. A large amount of attention is given to electricity and electrical engineering, with adequate training in physical and electrical engineering laboratories; all with special reference to the use of electricity on warships. Adequate time is given throughout the course to warship design, together with lectures on the construction of warships, on armor and armament, on submarine boats, on automobile torpedoes and other subjects relating

to the building and service of warships. The following schedule of subjects will give an idea of the arrangement of the course:

"Junior year, first term.—Naval architecture, displacement and stability; history of modern warship construction; warship design; advanced calculus; least squares; theoretical electricity; hydraulics; machine drawing; qualitative chemical analysis; Spanish.

"Junior year second term.—Naval architecture, surface of buoyancy, flooding compartments, docking, launching, etc.; theory of warship design; warship design; differential equations; applied mechanics; theoretical electricity (periodic currents); physical measurements; physical laboratory; organic chemistry; sanitation of ships; Spanish.

"Senior year, first term.—Naval architecture, waves, rolling, etc.; theory of warship design; warship design; steam engineering; drawing with steam engineering; applied mechanics; periodical electrical currents; physical laboratory; metallurgy of iron; Spanish.

Senior year, second term.—Naval architecture, resistance and propulsion, etc.; theory of warship design; warship design; steam engineering; applied mechanics; alternating current machinery; electrical testing; foundations; heating and ventilation; metallography; Spanish.

"Graduate year, first term.—Naval architecture, hydrodynamics, etc.; theory of warship design; warship design; marine engineering; dynamics of machines; steam engineering; engineering laboratory; theory of structures; electrical testing; electrical engineering; electrical engineering laboratory.

"Graduate year, second term.—Naval architecture, submarine boats, torpedoes, etc.; theory of warship design; warship design; marine engineering; electrical engineering; electrical engineering laboratory; engineering laboratory; thesis."

PROF. PRITCHETT'S PAPER DISCUSSED.

Prof. Cecil H. Peabody of the institute was the first to discuss the paper. He endeavored to illumine the subject since any list of courses without specifications is of necessity vague. He added that while the paper might seem to give undue attention to submarine boats that subject was really regarded as of secondary importance. In general the first two years at the institute are to cover accepted theoretical work, while the last two years will generally be devoted to practical application. The junior courses have been prescribed but the graduate year is yet subject to revision.

Prof. William Hovgaard, teacher at the institute, went into greater detail concerning the courses, emphasizing the fact that in a series of lectures the history of the development of the warship will be gone into, not especially as to names and dates, but in relation to causes and effect and how the different steps in development have been brought about. After the historical part will come the theory of design, in which the general principles for choosing and settling upon the elements of design, including the military features, will be defined and discussed. The last part of the lectures will deal with the engines of warships. The lectures will be accompanied by great combinations of data. The third section of the course will be devoted to an examination of working drawings which will be constantly checked by what the students will see in actual construction.

"I wish to express my pleasure," said Admiral Bowles, "with the means and methods of the institute. I also desire to accept Prof. Peabody's apology for the prominence given to submarine boats, but hardly regard the apology as necessary as the submarine affords an intricate problem to the student. The government of the United States has determined to prosecute its advanced courses in this country and it is well to know that there is an institution which can afford instruction not only to students of its own government but to other persons as well."

Naval Constructor Baxter spoke briefly upon the importance of manual labor in the shops and the necessity for instruction in shop management and shop administration.

Mr. W. D. Forbes spoke also of the great advantage of having technical men in charge of shops. He spoke of the revolution which one young man (not giving his name) had worked on his own establishment through technical knowledge. He added that if one would take a marine map of the world it would look like an anatomical study with all the lines radiating from one little heart—England—and he hoped to see the day when, through technical training, the lines would radiate from this country.

Mr. W. H. Jaques briefly noted that Admiral Bowles would undoubtedly recognize the importance of foreign technical training which had enabled the United States to take a leading place in the world of naval administration.

Mr. Stevenson Taylor spoke of the demand for graduates from the school over which he had the honor of presiding, meaning the Webb Academy for Ship Builders. He said that the students invariably found places as soon as they graduated and regretted that the members of the society were debarred by their opulence from a course of instruction there. The Webb Academy is a school for the needy.

Naval Constructor W. H. Varney, retired, recalled the days when the clipper ships of the United States were the best in the world. He said that the United States had lost its prestige as a maritime nation through its indifference to technical training—that is those nations which had made a feature of it had wrested the supremacy in ship building from the United States. He

*thought that the inventive genius of the American nation, assisted by technical training, would eventually regain supremacy.

COL. EDWIN A. STEVENS.

Col. Edwin A. Stevens, vice president of the Society of Naval Architects and Marine Engineers, was born in 1858 and was educated at St. Paul's school, Concord, and in Princeton college, graduating in 1879. He has lived all his life in Hoboken and his employment has been in various concerns doing business in that city. He took up engineering after leaving college and his main work has been in the designing of screw-ferry boats. He designed the first one of the class, the Bergen, and has also done work on smaller vessels and electric lighting engines.

PROGRESSIVE TRIALS OF THE SCREW FERRY BOAT EDGEWATER.

Col. E. A. Stevens, vice president of the society, then read his paper upon "The Progressive Trials of the Screw Ferry Boat Edgewater." In the preparation of this paper he was assisted by C. P. Paulding. The authors represented that the only excuse they gave for the presentation of the results of the trials of the Edgewater was the value of data of this class to designers. This excuse, if excuse it may be called, is indeed, ample for it is seldom that data of this character is available. Extended trial trips are usually confined to naval vessels and it is not always possible for obvious reasons, to make the results public. This was a point of thanks most forcefully presented by Prof. C. H. Peabody. It is to be regretted that the paper, consisting largely of delicate plates and drawings, is impossible of satisfactory reproduction in this running account of the meeting. Mr. F. L. Du Basque referred to a few important points brought out by the trial. The paper was, of course, commended as a valuable addition to the proceedings of the society. Similar trials have been run in but two other instances—those of the Bergen, recorded in Vol. XI. of the transactions of the Society of Mechanical Engineers, and of the Cincinnati, recorded in Vol. IV. of the transactions of the Society of Naval Architects and Marine Engineers.

FUTURE OF ELECTRICITY ON BOARD SHIPS.

A paper of great and most timely interest was read by Mr. F. O. Blackwell upon the subject "Probable Future Developments in the Use of Electricity on Board Ships." Mr. Blackwell is in charge of the mining and power department of the General Electric Co., Schenectady, N. Y. We quote from Mr. Blackwell's reading:

"The part played now by electric power in the design and operation of the latest steamships, especially men-of-war, is an important one, but it is my belief that the future promises for it an even more extended use. The object of this paper is to point out the improvements that are in sight in marine electric plants, the field for their profitable extension, and to call attention to some of the recent improvements in electrical engineering that may be advantageously employed on shipboard. There are three general subjects which I propose to discuss, namely, the substitution of steam turbines for reciprocating engines for driving the electric generators, the use of alternating current generators and motors instead of continuous current apparatus, and the operation of all auxiliary machinery on ships by electric motors. These subjects are, of course, interconnected, but they do not necessarily have to be all considered together. For instance, continuous current generators and motors may be used with steam turbines, and it may still be desirable to drive the auxiliaries by motors.

"The steam turbine cannot be regarded as a general substitute for the reciprocating engine, as its speed is too high for direct connection to most machinery or for the safe use of gearing. For driving electric generators, however, it is ideal. Within reasonable limits, the higher the speed of electrical apparatus the smaller, lighter and more efficient it becomes. We may even consider the electric motor and generator simply as a convenient speed-reducing and distributing mechanism which is more efficient than most mechanical connections. Compared with the reciprocating engines and slow-speed generators now used in our navy, a turbine plant can be designed which will have but one quarter the weight and take but one-tenth the space. It would also save weight in the structure of the ship on account of its lightness and freedom from vibration. The steam turbine can be used with a high degree of superheat (when superheated steam comes into general marine use, as it undoubtedly will before long), because there are no lubricated surfaces in contact with the steam, and a high vacuum can be obtained because there are no piston-rod packings to leak air. The entire absence of lubricating oil in the condensed steam is also a great advantage to avoid deterioration and foaming in boilers. The efficiency is very high, especially when we consider that it is the actual efficiency, including all mechanical and electrical losses, there being no such thing as indicated horse-power in a turbine.

"The steam consumption of, let us say, a 300-Kw. turbo-alternator at full load with dry steam at 200 lbs. pressure and 28-in. vacuum would be about 20 lbs. of steam per kilowatt hour, or 15 lbs. per electrical horse-power hour. The steam consumption at one-half load would be about 22 lbs. per kilowatt hour. There is no objection, therefore, to putting in large units and running them much of the time underloaded. In order to appreciate this

it should be contrasted with the present reciprocating compound dynamo engines, which take 30 to 50 lbs. of steam per kilowatt hour at full load, and 40 to 65 lbs. at one-half load. It is at least as efficient as the main engines at full power and, undoubtedly, much better than they are at cruising speed. Of course, it should not be forgotten that the average ship dynamo and engine now in use is of from 30 to 100 kilowatt capacity, and also that the high-speed alternator has a higher efficiency than the slow-speed continuous current generator, especially at low potentials when the commutator brush friction is high. The steam turbine can be used to drive continuous current generators, but not to as good advantage as an alternator on account of the high speeds.

ALTERNATING CURRENT SYSTEM.

"Alternating generators are made to deliver current with a single series of waves over one circuit, a double series over two circuits, or a triple over three circuits, and are known as one, two and three-phase machines. The electric impulses correspond to those of a single crank engine, a double cylinder with the cranks 90° apart, and a three-cylinder with the cranks 120° apart. The one-phase is the simplest arrangement, only two wires being required, and is that first employed on shore when lighting alone was done. The poly-phase (that is, two and three-phase) system permits the design of a cheaper and lighter generator and motor, and is therefore, at most, always employed to operate motors. In addition it gives a motor which will start with full torque, whereas the single-phase, like a single crank engine, becomes dead centered at starting, unless somewhat complicated starting devices are employed. As between the two-phase and three-phase systems, the two-phase requires four wires and the three-phase but three. One-third more copper is required for either one-phase or two-phase than is needed for three-phase under the same conditions. It is evident, therefore, that to supply power to motors the three-phase system is most economical, while for incandescent lamps, one-phase is preferable in order to make the lamp wiring as simple as possible. Fortunately, we can combine these two methods of distribution and get the advantages of both. The lighting should only be a small portion of the entire load of a ship power plant, and any one three-phase generator can carry it all single-phase without difficulty. The potential supplied for lighting must be perfectly constant in order to give good service and not burn out the lamps. The motors run practically as well with a variable as with a constant voltage. The alternator should therefore be made with a regulating device that automatically gives constant potential to the one-phase lighting circuit, even if the other branches of the three-phase circuit vary.

"Alternating current has come into extensive use on land principally because of the ease with which the potential can be raised or lowered by means of transformers or compensators without moving parts, and because higher potentials can be safely employed than with continuous current.

This, also, has an application for marine work as will be shown later. It is also an advantage of alternating current machinery that there is no magnetic field set up by the generators, motors, or by the constantly reversing currents in the wiring that can affect the ship's compass. Neither does alternating current cause electrolytic action should it pass through the iron work of the vessel.

"Alternating current generators: The best alternators are constructed with stationary armature and revolving field, so that the armature current flows directly to the circuit without passing through commutator or brushes. Continuous current is required to excite the fields so that a small direct current generator must be provided of about 1 per cent. of the capacity of the alternator. The alternator is more efficient, less liable to get out of order, and can be maintained and operated with less expense and labor than a continuous current machine. Both types can be compounded to give a constant potential for lighting. When two alternators are to be run in parallel they must be in exact synchronism, but this presents no difficulties, especially when they are driven by steam turbines of constant angular velocity. Throwing alternator in synchronism, however, takes a little more time and care than putting continuous current generators in parallel.

"In the continuous-current shunt-wound motor, the speed can be changed by varying the strength of the field current within certain limits and with nearly constant efficiency, as is now done with blower motors. In the series continuous current motors, the speed automatically varies with the load (a heavy load giving a slow speed and a light load a high speed) as in most of the hoist motors at present used. A continuous current motor may also be operated efficiently at any speed by varying the potential supplied to the motor, as for example the present type of electric turret control. The induction motor will not permit of any of these forms of control, and other less efficient methods must be substituted. There are two forms of revolving secondaries, or armatures, in use in induction motors. In one the winding consists of bars all joined together at the heads, and is known as the squirrel-cage or short-circuited armature. In the other the secondary is polar-wound and the ends of the winding are connected to a variable resistance, either inside the armature or external to it. In order to vary the speed two methods are used. The polar-winding can be connected to collector-rings so that the current in the secondary is carried to a controller which cuts in more or less resistance. This is known as secondary control. A

short-circuited secondary may be used of permanent high resistance. By varying the potential supplied to the motor, the current flowing in the secondary is increased or diminished, and this acting over the fixed resistance changes the speed of the motor. The former method is preferable, as it is more efficient and the power does not go into heating the motor and reducing its capacity, but is dissipated externally. The latter method, however, has the advantage of having only one set of wires carried to the motor, and is, therefore, superior for distant control. The windings of an induction motor can be connected so as to give two or more speeds by changing from, say, four to eight poles. With a short-circuited secondary this requires no change in the armature. The speed may also be varied by changing the periodicity of the system. A combination of these two methods has been employed to give a considerable number of speeds, at each of which the motor runs with full efficiency. The weight of induction and continuous-current motors is for ordinary speeds about the same. At high speeds, the alternating motor is lighter, while at slow speed it is heavier on account of the large number of poles and greater diameter required.

ALTERNATING WIRING.

In transmitting power by alternating currents, in addition to the loss due to the resistance of the conductors, there is an apparent loss of energy and an actual drop of potential caused by the inductance of the wires. The inductive drop is unimportant with small conductors, as used for lighting, but may be considerable with the large conductors and currents required for motors. The inductive loss may also be greatly increased if single wires are enclosed in iron tubes or run near iron work. If a complete circuit, that is two wires for one-phase or three wires for three-phase, are placed together the inductance is practically negligible. By using double conductor cable for single-phase and triple conductor for three-phase, alternating current may be run through iron pipes or along iron work without difficulty. The single-phase wiring for lighting will be nearly the same therefore as for continuous currents. The power circuits constitute over nine-tenths of the load, and must therefore be given careful thought. By employing three-phase current a saving of 25 per cent. is effected in conductors as compared with continuous current at the same potential. By increasing the power-circuit pressure to 220 volts, a further saving of copper is made. Two hundred and twenty volts requires but one-third the weight of conductors needed for 125 volts. The wattless current of induction motors will reduce the economy somewhat, but we can safely say that a 220-volt three-phase system can be operated with but one-third the copper of a continuous-current 125-volt, other things being equal. Comparing this alternating system with the existing 80-volt continuous current, the copper required will be but one-sixth; in other words, the wiring for a 1,200-Kw. three phase system will be no greater than that of a 200-Kw. continuous current.

Auxiliaries: Driving all auxiliaries, including the feed, circulating and air pumps by motors, I believe to be more efficient and to have many advantages over steam operation. It is argued because the exhaust from the auxiliaries is turned into the feed-water heaters and distilling apparatus, it makes no difference how much steam is consumed by them. This is true to a certain extent, but the energy lost by leakage and radiation in the piping and cylinders cannot be recovered. The hot steam pipes to the auxiliaries are most objectionable in themselves, and a source of constant trouble in service. The auxiliaries are much less efficient when they are operated only occasionally or at less than their full capacity when the ship is running at cruising speed or in port. The mechanical efficiency of the small engines is also very poor. Auxiliaries which take from 50 to 300 lbs. of steam per horse-power hour and have to be run by throttling the steam down to a fraction of the boiler pressure, as is often the case now, are so inefficient that the system is little better than heating the feed-water by steam directly from the boiler, which is evidently a poorer method than heating the feed-water in the boiler itself. The proper way is to get as much mechanical power as possible out of the steam before it is turned into the heater and its latent heat given up to the feed-water passing into the boilers. When the auxiliaries average 150 lbs. of steam per indicated horse-power hour, as they did on the Minneapolis, it means that $1\frac{1}{2}$ per cent. of the heat energy of the steam is converted into mechanical power. By taking steam from the main engines after it has partially expanded, a return of from 8 per cent. to 10 per cent. of the heat energy may be obtained in mechanical power. A pound of coal may only be worth a tenth of a cent, but the mechanical equivalent of its heat value, 5 H. P. hours, may be worth 5 cents, or fifty times as much. Steam for the feed-water heaters, distillers, evaporators, and steam heating should be taken from between the low and the intermediate cylinders of the main engine, or when that is shut down from some intermediate stage of the turbine wheels of the electric plant. By using motor-driven auxiliaries, the oil which is introduced into the feed-water by reciprocating engines is also done away with and the resulting troubles with boilers avoided. The combined mechanical and electrical losses in the generator, motor, and electrical transmission can be less than 20 per cent. With a steam economy in the turbo-alternator of 15 lbs. per horse-power hour, this gives a steam consumption for the motor-driven auxiliary of 18 lbs. or

about one-eighth that of the Minneapolis auxiliaries already referred to.

BASIS FOR PROPOSED POWER PLANT.

"In order to have a basis for figuring I have assumed that the U. S. S. Connecticut and Louisiana will be equipped with steam turbines and alternating apparatus for driving all the auxiliaries. These battleships were authorized by the last congress, and are being built at the Brooklyn navy yard and at Newport News. They are to have a trial displacement of 16,000 tons, a speed of 18 knots, and main engines of 16,500 H. P. The specifications of the navy department do not call for motors to drive the pumps, forced draft blowers, ash hoists, anchor windlass or steering engine. I have, however, made up a table to show what would be the running conditions were all machinery except the propelling engines driven by motors. The number and size of some of the auxiliaries have been changed to meet the needs of electric driving. In some cases the powers have had to be assumed, no data being at hand, and the list is only an approximate estimate to get at the total power needed under maximum and ordinary conditions. The maximum load is taken to be when the ship is going into action at full speed."

In the table to which Mr. Blackwell has just referred he gives to all machinery excepting the propelling engines a total rated horse power of 2,461; average maximum horse power, full speed in action, 767; ordinary horse power, cruising speed, 349, and port horse power, 399. This is the basis for the power plant which he lays out. Continuing he said:

"The specifications for the Connecticut and Louisiana now call for two separate power plants each containing four 100-Kw. generating sets. In order to take care of the other auxiliaries which the specifications did not contemplate operating by electric power a larger plant is required, and at the same time larger and fewer units can be used, which is permissible because of the high steam economy of the turbine on partial loads. The total nominal capacity of all the auxiliary apparatus is seen from the table to be about 2,500 H. P. Of this not more than 800 H. P. could possibly be in full operation at one time, even when in action and going at full speed, and not more than 400 H. P. under ordinary cruising conditions or in port, not including the anchor windlass. The electric power must be divided into two separate plants, each large enough to supply the maximum load of the entire ship. I would divide each plant into two units of 300 Kw. each. The four steam turbines and generators would therefore each have a rated capacity of 400 H. P. with an overload capacity of 600 H. P. In port or when cruising at slow speed, one 300-Kw. unit would be all that would ordinarily be required. The use of four units instead of eight will much simplify the electric installation. The proposed four 300 Kw. units would certainly not weigh more than one-half as much or take more than one-third the space of the eight 100 Kw. engines and generators which are to be installed.

"The three branches of a three-phase alternating circuit either can each be joined only at one end, known as the Y connection, or at both ends, known as the delta connection. In the (Y connection the potential between the terminals is 73 per cent. more than between the common or neutral point and one of the terminals. Assuming that the new standard generator potential of the navy (125 volts) will be used for lighting, and that the lamps will be connected between the neutral and one line, the potential between the three-phase lines will be 220 volts. This gives a single-phase low-potential wiring system without introducing any complications and a higher pressure power system. By grounding the neutral, the strain on the insulation might be limited to 125 volts, but I hardly think this necessary, as 220 volts is not a high enough potential to cause any trouble. If it were grounded, single-wire lighting circuits might be employed with the ship as a ground return. Such a system could not be safely used with continuous current on shipboard, on account of the danger of electrolytic action corroding the iron work or the currents setting up magnetic fields that might affect the compasses. The inductive drop in a single-wire system would probably make a two-wire preferable, however. The total number of incandescent lamps on the Connecticut and Louisiana will be about 1,200, requiring 60 Kw. with every lamp burning. Probably 30 Kw. is nearer the usual load, or, say, 5 per cent., of the two generators in use at one time. One leg of a 300 Kw. generator will carry this without difficulty, and the potential of the generator can be automatically regulated to give constant potential at the lamps."

ADVANTAGE OF CENTRIFUGAL PUMPS.

At this point in his paper Mr. Blackwell deals with various details regarding the auxiliaries—search lights, turret motors, steering engine, windlass blowers, etc. In the reading he passed all these but directed particular attention to the pumps. On this score he said:

"Centrifugal pumps have recently been built in Europe and this country for heads up to 500 ft. lift by using high speeds and having a number of runners in series. There will soon be no difficulty in obtaining these to replace reciprocating pumps for all purposes on shipboard with practically the same efficiencies and with but one-third the weight. These pumps are particularly well adapted to be run by electric motors. Their high speed gives a small, light and efficient motor. They avoid entirely all gearing,

valves, and reciprocating parts, and, consequently, much of the noise, vibration, and repairs of reciprocating pumps. They do not require much variation in speed in order to largely change their capacity. They can be used to maintain nearly constant pressure at constant speed with a variable delivery. If the outlet is closed, there is no great increase in pressure and the pump unloads itself like a blower. If the outlet is partially opened the pressure decreases somewhat and the pump begins to feed. With a constant head a small variation of speed will make all the difference between the pumps delivering full capacity and doing no work. With such pumps available there need be no reciprocating pumps on shipboard with the exception of those for air. Where these centrifugal pumps are to be run at widely different pressures or capacities, some of the runners may be cut out entirely or put in multiple with each other. Changeable pole motors can also be advantageously employed."

In conclusion Mr. Blackwell said: "I think the steam turbine is the coming method of driving generators. Its rotary motion, light weight, small size and high efficiency at all loads make it particularly suitable for marine use. Alternators are best adapted to be driven by high speed turbines, but alternating current has both its merits and demerits. For transmitting power polyphase current is most economical, and the induction motor for constant speed cannot be equalled for simplicity of construction and ability to stand hard usage. It does not, however, permit of as economical or exact speed regulation as a continuous current motor, although there are possibilities of the development of an alternating commutating motor which will meet these requirements. As the majority of motors on shipboard run intermittently at variable speed, the selection between continuous and alternating current should only be made after thorough investigation. It is not the purpose of this paper to advise any particular system, but rather to bring out for discussion the merits of all. As to the more extended use of electricity for all purposes I have no doubts. It permits the concentration of the generation of power in one place and its easy distribution over any distance and its divisibility into small or large amounts. The electric motor is efficient, reliable and clean. Its convenience and the ease with which it can be controlled make it suitable for every kind of service. Its universal adoption on shipboard will increase the economy of the ship, either making the coal supply more effective or giving increased weight applicable to guns or armor. But more important still, it will permit quicker and more accurate work with each piece of mechanism, and, therefore, adds to the efficiency of every man in the ship's crew."

MR. BLACKWELL'S PAPER DISCUSSED.

Mr. Blackwell's paper was especially timely owing to the increasing use of electricity for auxiliary machinery on board ship. Admiral Bowles declared that he was entitled to especial praise for the clearness with which he handled the subject and voted the paper to be most interesting.

"I am entirely in favor of the extended use of electricity for auxiliaries," said Admiral Bowles. "In the new battleships, for which contracts have just been let, we are using electricity for every auxiliary purpose except the steering engine and windlass. The navy department has taken up the subject of an electric steering gear but so far this form of steering gear has not been entirely satisfactory. I thoroughly believe in the centrifugal pump for minor purposes. Instead of an extended system of piping, which is troublesome and likely to get out of order, I believe in having pumps located in various parts of the ship for certain defined uses and operated by independent motors. There is objection, however, to the universal application of electricity. Some times a bit of machinery would get out of order and no one could tell what was the matter with it. There is another objection too—the chief engineer is not generally in favor of electricity because he cannot turn on the juice without asking permission as he can steam. This seems trivial but it is, nevertheless, important."

"It may appear strange," said Mr. James G. Winship, of the George A. Blake Mfg. Co. and the International Steam Pump Co., "but I have observed that electricians prefer to use steam for auxiliary purposes. I don't know whether it is because they doubt what they have to sell or not. Centrifugal pumps, operated by motors, have many points of commendation but also have their drawbacks."

Naval Constructor Varney, retired, said that long and large air ducts could be saved by using electrical fans, and that electricity had many advantages when applied to the problem of ventilation.

Lieut. Com'dr. William F. White discussed the problem of the wiring of the ship. He thought that it was not desirable to run wires in the passageways adjacent to the armor because in collision, or in the impact of a shell against the armor, the electrical plant is likely to become disengaged. He thought that there should be some arrangement for carrying the pipes fore and aft on amidship lines.

Mr. F. Merriam Wheeler declared that many of the auxiliaries on the Kentucky were ill proportioned and that they speedily got into bad condition. He complimented the paper, however, as one certainly well up in line with modern progress. He referred to the economy of the steam turbine, pointing out a few of its leading advantages. In the introduction to his paper Mr. Blackwell said that "when the auxiliaries average 150 lbs. of

steam per indicated horse power, as they did on the U. S. S. Minneapolis, it means that 1½ per cent. of the heat energy of the steam is converted into mechanical power." Mr. Wheeler referred to unfavorable conditions of machinery of the Minneapolis attending this average for auxiliaries, which he said should be taken into account.

Naval Constructor Varney, retired, said that the use of a centrifugal pump is much added to by having it low, even so far as to having it sometimes practically submerged. He asked Mr. Blackwell how such a condition would affect a motor and inquired as to whether or not it was likely to be short-circuited.

"In mining," replied Mr. Blackwell, "motors sometimes operate entirely under water. In that case they are entirely enclosed and the heat generated in the enclosure is counterbalanced by the water. In the case of which Mr. Varney speaks the motor would be water-jacketed."

A vote of thanks was tendered to Mr. Blackwell for his paper and an adjournment taken until afternoon.

SPIRITED AND LIVELY DEBATE.

Mr. Fairburn's Article on the Water-tube Boiler Question Starts a Controversy in which Chief Constructor Bowles and Mr. A. H. Raynal of the Engineering Department take part.

Rear Admiral Bowles, who it may be said in passing is one of the best presiding officers which it is possible to imagine, presided at the afternoon session of Thursday. The opening paper was upon "The Preliminary Official Trial of the United States Battleship Maine," by Assistant Naval Constructor J. W. Powell. In the absence of Mr. Powell a brief digest of the paper was read by Secretary Capps. There was no discussion whatever upon this paper.

MR. WILLIAM A. FAIRBURN.

Mr. William A. Fairburn has had a thorough technical training, graduating at Glasgow university with high honors. He has also had a sound practical ship yard education, working for three years as helper, fitter, loftsmen and riveter in an iron ship yard, and his drawing office experience is most complete and varied. Mr. Fairburn was chief draughtsman with the Bath Iron Works for a number of years. He left the Bath works to join with Mr. Charles R. Hanscom in the upbuilding of the Eastern Ship Building Co. at New London, Conn., where the two Great Northern liners are building. Mr. Fairburn is a member of the Institute of Naval Architects of Great Britain, the French Institute of Naval Architects, the American Society of Naval Engineers. Prior to his joining the Eastern Ship Building Co. he had had experience in the design and construction of fifty vessels of almost every type.



Mr. William A. Fairburn.

WATER-TUBE BOILER IN THE AMERICAN MERCHANT MARINE.

An elaborate paper upon "The Water-Tube Boiler in the American Merchant Marine," was contributed by Mr. W. A. Fairburn, of the Eastern Ship Building Co., New London, Conn. In the absence of Mr. Fairburn it was read in part by Mr. A. M. Main. This paper elicited a great deal of spirited discussion. Mr. Fairburn must certainly have spent a great deal of time in preparing this contribution to the proceedings of the society. It contains seventy pages of the large form in which the proceedings are made up, in addition to twenty pages of plates. First are a couple of pages of historical matter based on the fact, generally admitted, "that the water-tube boiler is not a new form of steam generator, but an old one resurrected." Then follows thirty-seven features which Mr. Fairburn sets forth as essential in the water-tube boiler that shall finally displace the well tried and favorite Scotch fire-tube boiler. Coming now to that part of the paper which deals with types of marine water-tube boilers we will quote fully, as in this part of the paper the Babcock & Wilcox was likened to the Niclausse and the result was a very spirited reply on this score from Mr. A. H. Raynal, now chief draughtsman of the bureau of steam engineering, navy department, but who was for a long time connected with the Babcock & Wilcox Co. Mr. Fairburn's introductory summary of the types of marine water-tube boilers follows:

"Many of the different types of water-tube boilers have been tried with more or less success in marine installations; some have

proved failures, while others have not as yet had a satisfactory opportunity of showing their merits or demerits. Classifying the boilers according to the means adopted for securing the circulation of water gives us three groups of types, which may be called, as suggested by Naval Constructor Bertin, of the French, first, boilers with limited circulation, then boilers with free circulation, and again boilers with accelerated circulation. In the first class, the principal characteristic is the absence of water reservoirs, and the Belleville boiler is an illustration of this type. The second group consists of boilers with practically horizontal tubes connected to vertical reservoirs. To this group belong such boilers as the Niclausse, Babcock & Wilcox, Durr, Lagrafel D'Allest, etc. The third group is composed of boilers having as a distinguishing characteristic tubes running almost vertical, connecting horizontal reservoirs. To this type belong such boilers as the Normand, Yarrow, Thornycroft, Mosher, Guyot Du Temple, Blechynden, Reed, White, Fleming, Ferguson, etc. It will be noted that the only boilers that in a general way fulfil the before stated requirements for a successful boiler for vessels of the mercantile marine are those with free circulation. This does not mean that the writer considers the other classes of boilers unsuitable for marine work, for boilers with accelerated circulation are absolutely essential where high speed and great power with light weight and small space is required. Such boilers as the Normand, Yarrow and Thornycroft are indispensable, if certain classes of marine construction are to be successful, but for the maintained severe work of the mercantile marine, where continued economy, reliability, rapid repairing and durability are great influencing factors, this type of boiler will never prove successful. They have as their field of usefulness certain types of small high-speed war vessels and torpedo boats; also steam yachts and small river, lake and coasting craft. If the builders of this type of boiler are not content with the broadness of this field, it behooves them to be very careful before recommending such boilers for deep-sea work, for failure in a few large installations will soon rob a small tube boiler of all the good reputation it ever possessed. Boilers with limited circulation, such as the Belleville, are likewise not suitable for use in the merchant marine; nevertheless, as this boiler has been fitted in large American merchant vessels, and as it is probably the best known large tube water-tube boiler in the world today, it will be considered comparatively in this paper. The boilers with free circulation can be divided into two cases—those with plain tubes and expanded ends, and those with "Field" tubes secured into water spaces at one end, with the other end free.

WATER-TUBE BOILER THE BOILER OF THE FUTURE.

The best steam generators of the former type are the Babcock & Wilcox and the Lagrafel D'Allest boilers. The latter possesses many excellent features, but as it has never been used in America, and as it is not considered as good as the Babcock & Wilcox boiler for merchant work, the Babcock & Wilcox boiler, which has been used extensively in this country, will be discussed as the representative boiler of this type. The second class of steam generators consists of many boilers, of which by far the best are the Niclausse and the Durr. The latter has proved very successful in Germany; it is a good economical steam generator, but as it lacks many of the most desirable features of the Niclausse boiler, and as the Niclausse boiler is built in this country very extensively, and is being used in the mercantile marine, we will consider the Niclausse boiler as the representative boiler of this type. It is undoubtedly a fact that the Babcock & Wilcox and Niclausse boilers approach nearer to the requirements of the ideal water-tube boiler for the mercantile marine, than any other boiler now being constructed. These boilers both have faults, but their merits greatly outweigh these faults, and both could be used today with good success in merchant vessels. The successful water-tube boiler of the future that will ultimately displace the Scotch boiler for deep-sea merchant work will be designed upon experience gleaned from the working of such boilers as the Niclausse and the Babcock & Wilcox.

The wide scope of Mr. Fairburn's paper beyond this introduction, which is its base, may be judged from the following sub-headings: Relative advantage of straight large-tube water-tube boilers with free circulation compared with cylindrical fire tube boilers; relative advantage of cylindrical fire-tube boilers compared with straight large-tube water-tube boilers with free circulation; features in design of water-tube boilers; operation of water tube boilers and their location in ship; the Niclausse boiler, its special advantages, possible criticism of design, etc.; the Babcock & Wilcox boiler, its special advantages, possible criticism of design, etc.; the Belleville boiler, possible advantages, possible criticism of design, etc.; mechanical stokers; liquid fuel, its advantages and disadvantages; cost of boilers.

Mr. Fairburn's conclusion is that "the water-tube boiler is the boiler of the future and its ultimate universal adoption is positive. An ideal or entirely satisfactory water-tube boiler has not as yet been produced, but such boilers as the Babcock & Wilcox and the Niclausse will probably prove the forerunners of a type of boiler that will fulfil the necessary essentials and obtain the confidence of designing and operating engineers. Mechanical stokers and liquid fuel will assist the water-tube boiler in its progress and advance into favor, and although the former will be used extensively in stationary plants, its application to marine work

will be somewhat limited, for fuel oil will become very popular afloat and entirely supplant coal in many trades and on many seas."

DISCUSSION OF MR. FAIRBURN'S PAPER.

It may be well to note, on account of some features of the discussion that followed the reading of Mr. Fairburn's paper, that he is the naval architect at the works of the Eastern Ship Building Co., New London, Conn., where two of the largest ships ever undertaken in the world are being built and are to be fitted with Niclausse boilers. This circumstance probably had much to do with a criticism of the paper from A. H. Raynal that reiterated over and over again, objection to coupling the Niclausse with the Babcock & Wilcox boiler. Mr. Raynal, who is now chief draughtsman with the bureau of steam engineering, navy department, was associated with the Babcock & Wilcox interests for a great number of years, had much to do with the design of the boiler of that name since its inception, and could hardly find words to express indignation at what he termed an "everlasting effort in the paper to place the Niclausse boiler in good company." He said that the two boilers were coupled so closely as to leave great doubt whether there was any difference at all between them; that they should not be classed together; do not belong to the same type; should not be hyphenated, and this is almost what the entire paper amounts to. The Niclausse, he declared, is more allied with the Durr and Montupet boilers, and of these three the Durr, if anything, has proven most successful in actual practice.

"It is to this feature of the paper," said the speaker, "which as an engineer somewhat acquainted with the history and development of the water-tube boiler in the United States, I thoroughly object. It seems that the writer recognizes that the Babcock & Wilcox boiler has come to the front in an indisputable way and he desires to hitch onto it the Niclausse boiler, somewhat after the manner of the builders of engines of the Corliss type, who created the hyphenated Reynolds-Corliss, Harris-Corliss, Fishkill-Corliss, etc., etc."

Then from notes Mr. Raynal took up numerous paragraphs in Mr. Fairburn's paper with a view to pointing out conditions which he said were fulfilled by the Babcock & Wilcox boiler but lacking in the Niclausse. In all of these references he protested that the boilers should not be classed together. In one of the introductory paragraphs to his paper Mr. Fairburn says: "The only large installations of water-tube boilers made in American merchant ships have been branded failures, Babcock & Wilcox boilers being condemned in one vessel and Belleville boilers in two others." Of course it is understood that the ships referred to as regards Belleville failures are the North West and North Land of the great lakes, while La Grande Duchesse, a Plant Line vessel, is the steamer referred to as a failure with Babcock & Wilcox boilers. On this score Mr. Raynal said: "I deny, emphatically, the failure of Babcock & Wilcox boilers spoken of in the paper and challenge the writer to bring proof. It is true that Babcock & Wilcox boilers were taken out of the Grande Duchesse, but under what circumstances? It would have been worth a great deal to the engineering profession had the conditions been ventilated in court and reasons brought out for condemning a battery of boilers that had been installed to develop 5,600 H. P. and that had actually developed over 8,000 H. P. continuously from New York to Savannah. The true history of this matter forms one of the grandest proofs of the safety and efficiency of these boilers. On the same page the writer uses as an argument the statement that the principals of the company on the lakes, in spite of unsatisfactory experience with Belleville boilers, prefer boilers of the straight-tube, free-circulation type for the vessels which they are building at New London. This argument can not amount to much until experience has shown their judgment to be correct. Let it be seen first what the results are after the boilers have been tried."

"Another statement in the paper," said Mr. Raynal, "that to the effect that the water-tube boiler is not at present as economical in continuous steaming as the best type of fire-tube boilers is unwarranted. Water-tube boilers have been proven economical, and in this respect they have failed only when improper baffling was arranged in them. We have definite proof that not only are the water-tube boilers as good in economy when properly designed but that they are even more economical than Scotch boilers. One of the most convincing proofs of this statement will be found in reports of tests of the boiler for the U. S. S. Cincinnati. Not only was this boiler eminently economical in the trial ashore but the almost phenomenal results with this ship on her late cruise have demonstrated that the results obtained ashore are obtainable afloat, even when firing is handicapped by a complement of green firemen and under the severe exigencies of actual service, requiring the ship to be ready for any emergency at a moment's notice. And again the author of this paper refers to 'a great difference between the performance of a water-tube boiler clean and new and when the exterior of the tubes are badly quoted with soot.' In this regard it may be said that a hot air supply, Howden draft if you will, is equally as applicable to the water-tube boiler as to the Scotch boiler, and will remedy this evil to a large extent and should be resorted to for obtaining highest efficiency, especially when inferior grades of fuel are used."

"When the author of this paper says of the Babcock & Wilcox boiler that 'its defects can be practically summed up in one

clause—difficulty in keeping clean, he gives the greatest possible praise to that type of boiler, for if this is the only objection to be raised to the Babcock & Wilcox boiler, and its very existence to this day disproves the truth of this statement there is nothing left but the conclusion that the Babcock & Wilcox boiler is one very close to perfection."

The speaker's conclusion, still reading from notes, was as follows: "The only motive that has prompted me to depart from the rule of abstaining from public discussions is the circumstance that in days gone by I was closely allied with the Babcock & Wilcox boiler. From the first days of its inception up to the time that wrought steel headers were made, I believe every detail of Babcock & Wilcox boilers was drawn by my hands. My close connection with Stephen Wilcox and Geo. H. Babcock—men to whom this country is indebted for this marvelous production in steam engineering—may serve as an excuse for the special interest I have shown in this matter. My purpose has not been to condemn any type of boiler. I have simply tried to prove that the Babcock & Wilcox boiler can and must stand on its own merits and as a special type must not be connected with any other kind of boiler."

Mr. F. L. Du Basque took issue with the statement in Mr. Fairburn's paper that all water-tube boilers are more expensive to operate than the ordinary Scotch type. He said that during a period covering six years he had made tests with four kinds of water-tube boilers and that the up-keep worked out at less than half that of the up-keep of the shell boiler. He held the small tube boiler to be worthy of consideration.

"How about the extra number of firemen that have to be employed?" asked Admiral Bowles.

"It requires more skill to operate a water-tube boiler," replied Mr. Du Basque.

"When water-tube boilers are as well known as Scotch boilers," said Mr. A. H. Raynal, "they will not require greater skill in operation. It will be exactly as it was in the case of the vertical, inverted rapid-working engine as against the old beam engine. We are familiar with both types now. In the past fifty years we have not advanced at all in our ability to make a pound of coal evaporate a greater amount of water. We have to burn so many pounds of coal to evaporate so much water, as we did half a century ago. When ships are designed they are designed for maximum power, and economy of boiler operation is lost sight of entirely."

"The point of economy in the operation of the boiler does not appear to be cleared up," almost drawled Admiral Bowles. "Can you account for the large increase in the engine-room staff which is laid to the water-tube boiler?"

"I am not aware that that is so," replied Mr. Raynal.

Mr. W. I. Babcock then arose and said that water-tube boilers had been installed in a few vessels on the great lakes and that such installation had resulted in an increase of 50 per cent. more help in the engine room, including water-tenders.

"That corresponds with the chair's information," added Admiral Bowles.

"I cannot see," said Mr. Du Basque, "any reason why the extra force is required. No more coal is used under the boilers and there is no added service further than to attend to the extra feeding apparatus; and the same corps of water-tenders can easily attend to a 2,000-ton ship equipped with water-tube boilers as with Scotch boilers."

"The trouble is that there is a tendency in this age," said Mr. D. J. Moore, "for every one to do less work. The trouble is that men don't do half the work nowadays that they formerly did—at any rate they don't do the work that one man did thirty years ago. I have done firing and it doesn't require any more firing with water-tube boilers than with Scotch."

"Here is an example which is absolute," said Mr. Raynal. "The cruiser Cincinnati was originally fitted with Scotch boilers. The greatest speed she ever made was 10 knots. The Scotch boilers were taken out and Babcock & Wilcox boilers were installed in their place. Now, burning the same amount of coal as she did with her Scotch boilers, she made 15.540 knots. There was practically no change whatever in the vessel except that her high-pressure cylinder was reduced in size a little."

"The chair must rule that example out," said Admiral Bowles. "When the Cincinnati had Scotch boilers the coal was not burned but simply baked by firing."

"I should say," said Mr. R. L. Newman, "that the reduction in the high-pressure cylinder would have had something to do with the increased speed, since by that means higher power of steam would be obtained."

"The measure of power is the low-pressure cylinder," said Mr. Raynal.

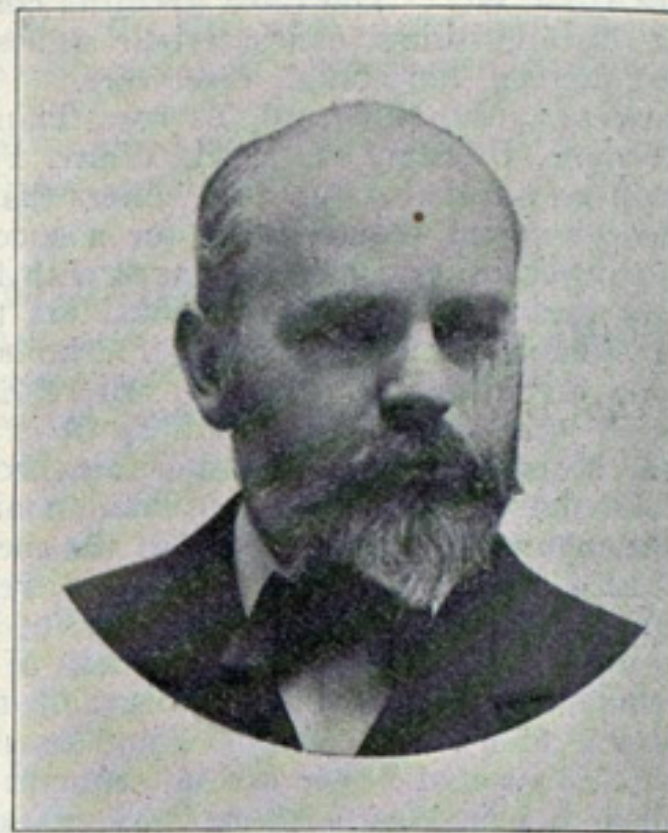
"The chair is perfectly aware that the case of the Cincinnati has not the slightest bearing on this subject," said Admiral Bowles. "When the Cincinnati was equipped with Scotch boilers the boiler room was so constructed that it was impossible to get sufficient fresh air into it to burn the coal. It simply baked the coal."

"I will not attack the Babcock & Wilcox boiler," said Mr. W. I. Babcock, "because I may get into a controversy with Mr. Raynal. Nor will I attack the Niclausse because some one may get up to defend it. But it seems to be pretty safe to kick the Belleville boiler. These boilers were in the lake steamers North

West and North Land for nine years and I am informed that they ran one year with satisfaction. They were taken out last year and replaced with Scotch boilers. On the round trip from Chicago to Buffalo they burned 1,150 tons of coal with the Belleville; they now burn 750 tons with the Scotch. The Scotch boilers moreover occupy only two-thirds of the space occupied by the Bellevilles. The Bellevilles also weighed, I am informed, 100 tons more than the figures given in Mr. Fairburn's article."

PROF. CECIL H. PEABODY.

Prof. Cecil H. Peabody has been prominent in scientific councils for a number of years. His life work has been with the Massachusetts Institute of Technology. He was graduated from the Institute in 1877 and was made assistant professor in 1884. In 1893 he became professor of naval architecture and marine engineering, which chair he has occupied since. He has contributed many papers to scientific bodies. His contributions, evincing great labor and research, to the meetings of the Society of Naval Architects and Marine Engineers have been especially valuable. Nor have the prepared contributions themselves been the only service, for whenever the papers on abstruse subjects have been read, Prof. Peabody's clear methods of discussing them have been much appreciated.



Prof. Cecil H. Peabody.

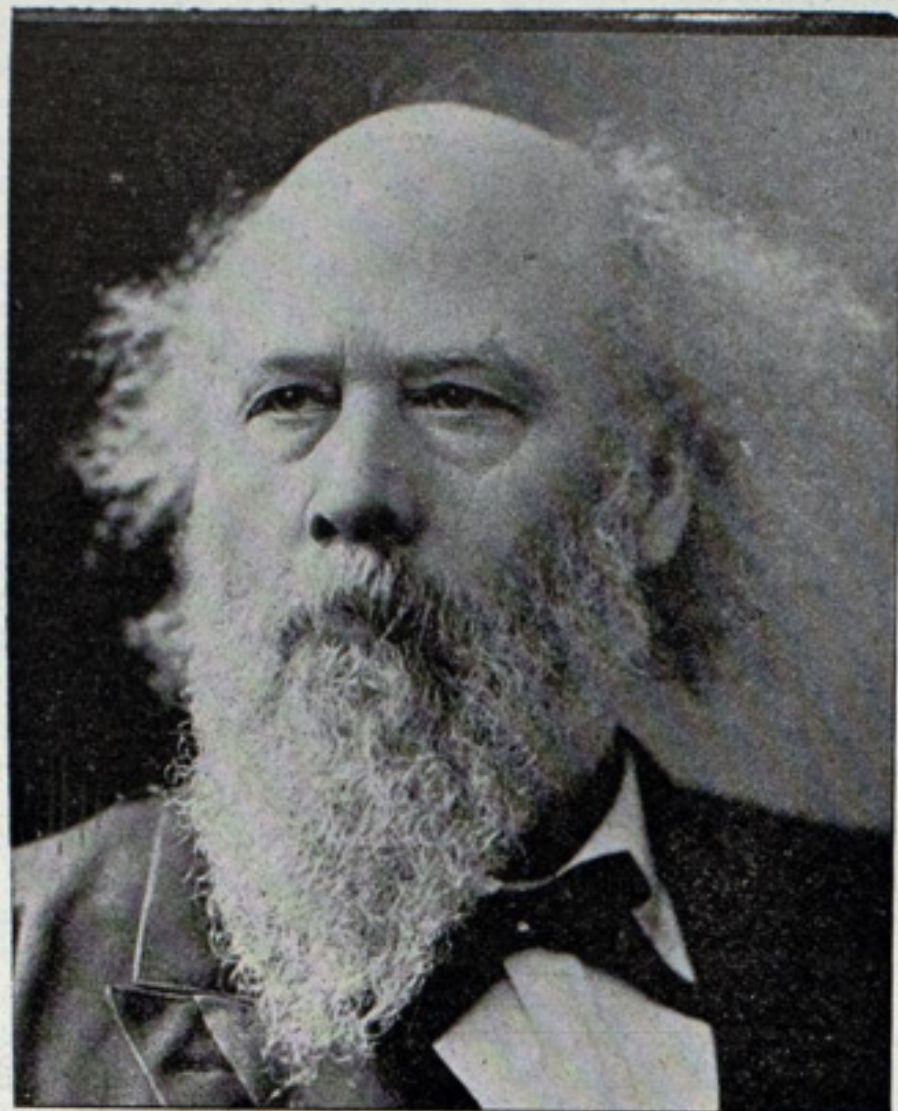
PROBLEMS ON THE SURFACES OF BUOYANCY AND WATER LINES.

The closing paper of the first day's session was Prof. C. H. Peabody's paper upon the subject, "Some Problems on the Surfaces of Buoyancy and of Waterlines." Prof. Peabody said that the most fundamental and complete investigation of the stability of ships is that which depends on the geometry of the surfaces of buoyancy and waterlines. Like so much of the theory of naval architecture the geometry of the surfaces is due to French writers on naval architecture, and so far as he is aware, nothing has been published on this subject in English. Prof. Peabody excepts, however, "Notes on the Properties of Floating Bodies" by Naval Constructor J. J. Woodward of the United States navy, which was printed privately at the Massachusetts Institute of Technology. Prof. Peabody says that the methods used by the French writers, though convincing to those who are familiar with them, do not appeal to those who are accustomed to English works on naval architecture; consequently he thought it proper to present to the society some problems on the surfaces of buoyancy and waterlines, using methods which are more familiar. He did not attempt to read his paper throughout as it was not susceptible readily to such translation. There was no discussion upon it. An adjournment was then taken for the day.

REAR ADMIRAL GEORGE WALLACE MELVILLE.

Rear Admiral George Wallace Melville is the son of Alexander Melville and Sarah Doughter Wallace. He was born Jan. 10, 1841, in New York city. He was educated in the public schools of that city and later passed through the Polytechnic school of Brooklyn. He also received further instruction in mathematics in a religious academy in Brooklyn. His first employment was in the engineering works of James Binn of East Brooklyn. On July 29, 1861, at the age of twenty years, he became an officer of the engineer corps of the United States navy. Although a junior officer Melville saw much active service during the war. He was for a brief period on the gunboat Michigan on the great lakes but was speedily transferred to the sloop Dakatoh of the North Atlantic fleet. With her he served during the shelling of Lambert's point and the capture of Norfolk, Va., the Dakatoh acting as guardship during the night and morning of the destruction of the Merrimac off Craney island, Norfolk harbor. He was with the fleet that cleared the James river in Virginia as far as Fort Darling, Drury's bluffs. Later he was attached to the fast side-wheel steamer Santiago de Cuba, the Tonawanda and the screw sloop Wachusett. He was on the Wachusett when she rammed and captured the Confederate cruiser Florida in the port of Bahia, Brazil. When the war was ended Melville was ordered to the Tacony and with her served in the Mexican gulf during the French occupation and evacuation of Mexico. Later he joined the gunboat Penobscot, then cruised to Brazil in the flagship Lancaster then to the Arctic in the steamer Tigress; then to China and Japan in the flagship Tennessee; again to the Arctic in the steamer

Jeanette and yet again in the Thetis for the relief of the Greely expedition. Then a short term on the Atlantic closed his service



Rear Admiral George Wallace Melville.

afloat. For the past twelve years he has been engineer-in-chief of the navy.

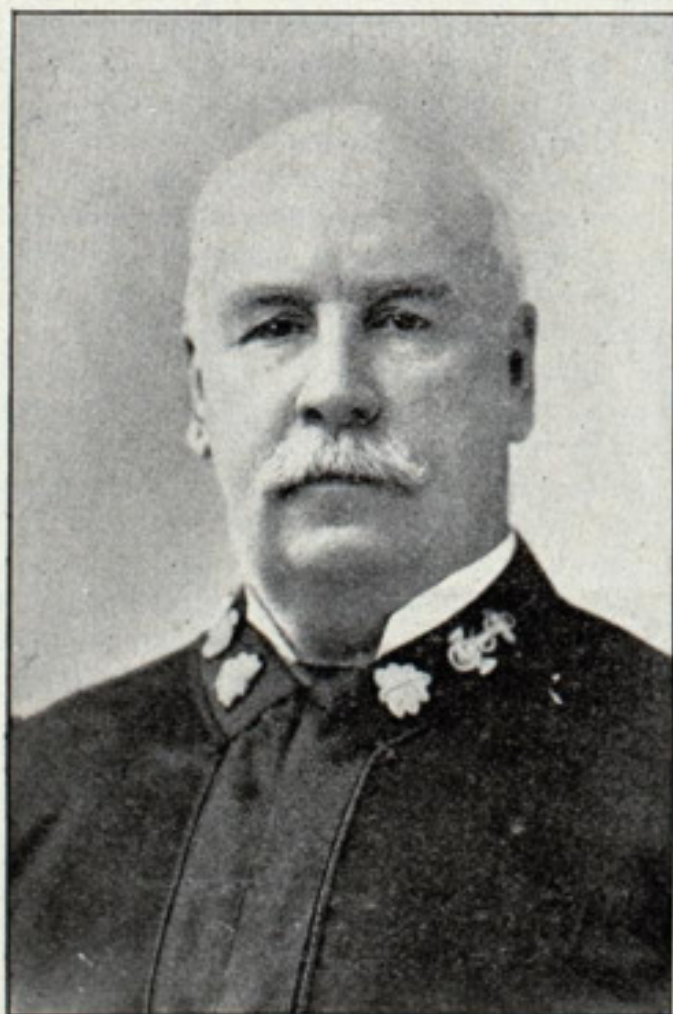
THE SECOND DAY'S SESSION.

It Began in even more Lively Fashion than that of the First Day—The Navy Department well represented in papers—Mr. Dickie creates a storm.

The session of Friday morning was called to order by Col. Edwin A. Stevens, vice-president of the society. The first paper to be read was that prepared by Rear Admiral George Wallace Melville, chief of the bureau of steam engineering, navy department, upon the subject, "The Vibrations of Steamships, With Special Reference to Those of Second and Higher Period." The paper was really a sequel to the discussion of last year on the balancing of marine engines when, it will be recalled, both Admiral Melville and Naval Constructor D. W. Taylor contributed papers. It was to clear up the question of the importance of vibrations of periods higher than the first that the paper was submitted. Admiral Melville was not present but the paper was given a most intelligent interpretation by Prof. Durand who read its most essential features. Mr. Taylor submitted a written discussion of the paper, which was, in his absence, read by Secretary Capps. There was some minor desultory discussion upon Melville's paper and Taylor's reply.

REAR ADMIRAL CHARLES O'NEIL.

Rear Admiral Charles O'Neil entered the navy in July, 1861. He received his education in the public schools of Roxbury, a suburb of Boston. Before entering the navy he made two voyages to the East Indies and on the second voyage he was wrecked in the Indian ocean. He drifted about in a small boat for five days before he was picked up. His first service in the navy was on the sloop Cumberland, in which he participated in the attack on Fort Hatteras and Clark, and in the engagement with the Confederate ironclad Merrimac off Newport News, Mar. 8, 1862. In this affair the Cumberland went down with colors flying. O'Neil was promoted for gallantry on this occasion. His next service was on the gunboat Tioga of the James river flotilla. Later he served



Rear Admiral Charles O'Neil.

as navigator of the gunboat Rhode Island and took part in both attacks on Fort Fisher. His next service was in the European squadron on board the Shamrock. He took the Marblehead to the Keil canal ceremonies. While on shore Admiral O'Neil has been engaged in ordnance work. He has been twice superintendent of the naval gun factory at Washington and in a great measure its development is due to him. He is responsible for the introduction of smokeless powder into the navy and through his efforts a government factory for its manufacture has been established at Indian Head near Washington. Admiral O'Neil is at present the chief of the bureau of ordnance and has brought the department up to a high state of efficiency.

DEVELOPMENT OF MODERN ORDNANCE AND ARMOR.

Rear Admiral Charles O'Neil's paper upon "The Development of Modern Ordnance and Armor in the United States" was read by Mr. W. D. Forbes, who evinced genuine sympathy with the subject and said that the admiral was to be commended for bringing together such a mass of historical data. This was a point, too, enlarged upon by Col. E. A. Stevens, who said that such sources of historical information are impossible to the layman and should be preserved. Admiral O'Neil's paper, owing to its value, is given in full as follows:

The development and manufacture in the United States of modern ordnance afford a striking illustration of progress made in those interesting branches of science, and it is the purpose of this paper to review briefly the most prominent facts in connection therewith. At the present time, when anything pertaining to ships of war, their armament, and military science in general excites so much popular interest, it is difficult to understand the apparent indifference that prevailed in this country with respect to them for a number of years following the civil war of 1851-'65, notwithstanding the fact that the serious attention of all other maritime nations of importance was given to efforts to improve them, and that marked improvements were in fact being made abroad. This was probably due in part to the fact that the country had had enough of war, and was more interested in recovering from its dire effects and readjusting itself to new conditions than in the consideration of naval or military matters except so far as pertained to a reduction of both branches of the public service. Another reason may have been the very uncertain status of the arts so far as ships of war and more efficient ordnance were concerned, as no well established line of development was in sight in the early sixties, either as regards material or method of construction for ships or guns, except that the day of wooden ships and cast-iron guns had gone by.

It should be said, however, in justice to the several chiefs of ordnance of the navy, that from year to year they clearly set forth in their annual reports to the secretary of the navy the wretched and inefficient character of our naval ordnance as compared with the standards of the day, and recommended that steps be taken to re-arm the entire navy with modern rifled cannon, calling attention to the progress being made abroad and to our inferiority in such matters. This was notably the case from 1873 to 1880, when Commodore Wm. N. Jeffers was chief of the bureau of ordnance.

As is generally known, our naval ordnance for some years prior to and during the civil war consisted chiefly of cast-iron, muzzle-loading, smooth-bore guns of the Dahlgren type, designed in 1850-'51 and introduced into the navy soon thereafter. During the civil war a considerable number of Parrott rifles were introduced both into the army and navy. These guns had cast-iron bodies, reinforced over the powder chamber by a wrought-iron hoop, which was shrunk on. At the commencement of the year 1861 the ordnance of the navy consisted of 2,830 smooth-bore guns, 2,474 of which were of old type and 356 being of the Dahlgren type. In addition there were 136 12 and 24-pounder boat guns. A total of 2,966 guns. Five hundred and fifty-five guns, in addition to a number of howitzers, were mounted on ships of the navy in commission, as follows: In frigates, 100 guns; sloops, 232; storeships, 7; screw frigates, 12; first-class steam sloops, 90; side-wheel steamers, 40; second-class steam sloops, 45; third-class screw steamers, 28; steam tenders, 1; total, 555. The remaining guns were either on board vessels in ordinary, on receiving ships, or parked in the several navy yards on the Atlantic coast. On Nov. 1, 1863, the total number of naval guns was 5,777. Of this number, 4,746 were smooth-bores (1,197 being of the Dahlgren type), 691 were Parrott rifles and 338 were rifled howitzers. This number was subsequently increased, and a number of 60-pounder Parrott rifles were also manufactured. A considerable number of Parrott rifles were put in service and were favorably regarded until several of them burst, from one cause or another, the records of the navy department showing that two 150-pounders, fifteen 100-pounders, one 80-pounder, three 30-pounders, and three 20-pounder burst during proof or in service; and it is stated that several Parrott rifle guns burst at Morris island in 1863 during Gen. Gilmore's operations before Charleston, S. C. A board of officers was convened to investigate the cause of the bursting of the guns referred to, and the conclusion arrived at was that it was due to the premature bursting of loaded shells in the bores of the guns, and that these explosions were due to the powder charge of the shells being ignited by friction caused by the rotary motion of the shells.

In the year 1877 a 100-pounder Parrott was converted into an 80-pounder breech-loader by cutting off the breech end and inserting a steel liner, the latter being screwed into the body of the gun after the latter had been expanded by heating, the old band over the powder chamber being replaced by a larger one. Ten guns in all of this class were converted into breech-loaders. In the year 1878 and following, twenty-eight 60-pounder Parrott rifles were converted into breech-loading guns by cutting off the face of the breech and inserting a steel-lining tube about 4 ft. long, which was screwed into the cast-iron body of the guns. These guns answered their purpose fairly well, and remained in service a number of years, though some of them are known to have burst, notably two on board the practice vessel *Standish*, attached to the naval academy.

THE OLD CAST-IRON SMOOTH BORES.

The cast-iron smooth-bores in general use at the time of the civil war were those of 15, 11 and 9 in. caliber. The former were carried exclusively as turret guns of monitors; the 11-in. were used as pivot guns and the 9-in. for broadside batteries of all the more important vessels. As these guns are practically unknown to the present generation and have nearly all been sold as old iron, except such as have been donated to soldiers' monument associations, grand army posts and municipalities, it may not be uninteresting to refer to them in some detail by way of comparison with the ordnance of to-day. The 15-in. gun weighed 42,000 lbs. (18.7 tons); its length over all was 181 in. (15 ft. 1 in.); its maximum diameter was 48 in.; its ordinary charge consisted of 35 lbs. of black cannon powder and a spherical shell weighing 350 lbs. Under extraordinary conditions such guns might under the regulations be fired twenty rounds "at ironclads at close quarters," using 100 lbs. of hexagonal or cubical powder and solid shot weighing 450 lbs. Under the latter conditions a muzzle velocity of 1,600 foot-seconds was attainable, with a corresponding muzzle energy of 7,997 foot-tons. Such being the most powerful guns afloat in the navy in 1861, it will be interesting to compare its muzzle energy of 7,997 foot-tons with that of the most powerful guns afloat to-day, namely, the latest type of 12-in. rifle, whose muzzle energy is 46,246 foot-tons. The old 15-in. smooth-bore, therefore, when fired with 100 lbs. of powder would develop 427 foot-tons energy per ton of gun as against 872 foot-tons energy per ton of gun in the case of the 12-in. rifle, which weighs 53 tons. The 11-in. smooth-bore gun weighed 16,000 lbs.; its length was 13 ft. 3.7 in. (about one-half that of a modern 6-in. gun); its charge was 27 lbs. of black cannon powder and a spherical shell weighing 166 lbs. Under these conditions its muzzle velocity was 1,062 foot-seconds, with a corresponding muzzle energy of 1,300 foot-tons. The 9-in. smooth-bore gun weighed 9,000 lbs.; its length was 11 ft.; its charge was 10 lbs. of black cannon powder and a spherical shell weighing 70 lbs. Under these conditions its muzzle velocity was 1,320 foot-seconds, with a corresponding muzzle energy of 847 foot-tons. The old 9-in. gun with its 847 foot-tons muzzle energy was the favorite broadside gun of our finest frigates during the civil war. Today the 6-in., 50-caliber rifle, with a muzzle energy of 5,836 foot-tons, is the favorite broadside gun of our battleships and cruisers. The muzzle energy of the latest type of 12-in. rifled gun is fifty-four times as great as that of the old 9-in. smooth-bore; so that one round of a modern 12-in. gun develops as much energy as would one round from each gun of a fifty-four-gun frigate armed with 9-in. smooth-bore guns.

In the year 1876 and following, fifty-one 11-in. smooth-bore guns were converted into muzzle-loading rifles of 8-in. caliber by the insertion of a wrought-iron coiled and welded tube or liner, the body of the gun being bored out to a diameter of 12 in. to receive the liner, which was 2 in. thick. This increased the weight of the gun from 16,000 to 18,000 lbs. The charge for the converted guns consisted of 35 lbs. of black hexagonal powder and an elongated cast-iron projectile weighing 180 lbs. Under these conditions its muzzle velocity was 1,450 foot-seconds, with a corresponding muzzle energy of 2,627 foot-tons, an increase of muzzle velocity of 388 foot-seconds and of muzzle energy of 1,327 foot-tons, due to such conversion. These were considered the most effective guns in the United States navy before the introduction of the high-power, built-up steel guns in the year 1884.

PROGRESS OF BUILT-UP GUNS IN OTHER COUNTRIES.

Prior to the introduction of modern ordnance in the United States navy, great progress had been made by other countries in the manufacture and development of guns built up of steel forgings. From the year 1865 to 1883 the navy was not only at a standstill but dwindled into insignificance as its wooden ships were dropped one after another from the navy list as they got beyond repair, until we had but a shadow of a navy remaining, and our few obsolete ships and antiquated guns excited the ridicule of foreign powers, and were a source of deep mortification to the officers of the navy. In the annual report of the secretary of the navy (Hon. Wm. H. Hunt) for 1881, he remarks: "The condition of the navy demands the prompt and earnest attention of congress. Unless some action be had in its behalf it must soon dwindle into insignificance." In November, 1882, Hon. Wm. E. Chandler, then secretary of the navy, in his annual report, says: "Having no effective guns, it is the duty of the government to begin their manufacture immediately." He further added: "The country is not now capable of making the steel forgings necessary

for heavy rifled cannon; they must therefore be procured from abroad or inducements offered to steel manufacturers to engage in their production."

Such was the state of affairs as regards modern ordnance in the navy in 1882. As early, however, as 1878, the chief of the bureau of ordnance (Commodore Jeffers) designed a 6-in., built-up steel, breech-loading rifled gun, and made every effort to obtain the forgings for its manufacture in the United States, but after repeated failures was obliged to purchase the jacket for this gun in England, although the tube was successfully made in the United States. This gun, the first improved breech-loading rifle made in the United States, was finished and put on the naval proving ground at Annapolis in 1882, where it performed most useful work in the development of brown prismatic powder, the manufacture of which was, about that time, through the efforts of the bureau of ordnance, introduced into the United States. This first 6-in. gun, although full up to date at the time it was designed, would to-day be considered as very low-powered, having a muzzle velocity with a 100-lb. projectile of only about 1,800 foot-seconds. The navy department is properly entitled to the entire credit for developing the manufacture of modern breech-loading, all steel, built-up rifles in the United States. In 1883 congress authorized the construction of four modern vessels, namely, the cruisers *Atlanta*, *Boston* and *Chicago*, and the despatch boat *Dolphin*, and also appropriated money for the completion of five double-turreted monitors then in an unfinished state, and it became necessary to supply them with modern guns, and funds thus being available, the bureau of ordnance began the installation of a plant for the manufacture of guns at the Washington navy yard, which has since developed into one of the largest and best equipped ordnance factories in the world. At the same time plans were prepared for high-power, steel, breech-loading cannon of all calibers, designed to give a muzzle-velocity of 2,000 foot-seconds, that being the highest standard of the day. Great credit is due to the late Rear-Admiral Montgomery Sicard, U. S. N., who was then chief of the bureau of ordnance, for his masterly grasp of the situation, and for the skill and ability exercised by him and under his direction in designing and introducing an entirely new armament into our new naval vessels. Admiral Sicard not only knew what was wanted, but had the courage of his convictions and the executive ability to carry them out. He was probably the most scientific and highly educated ordnance officer the navy has ever had, and thoroughly understood the science in all its branches.

OUR FIRST MODERN GUNS WERE MADE IN ENGLAND.

As there were no establishments in the United States then (1883) equipped for the manufacture of gun forgings, orders were placed in England with Sir Joseph Whitworth & Co. and Chas. Cammel & Co. for three sets of forgings for 10-in. and for eight sets for 8-in. guns. The Midvale Steel Co. of Philadelphia undertook the manufacture of the smaller gun forgings, and supplied fifty-nine sets for 6-in. guns before any other establishment in this country was in condition to supply any; that is, between the years 1883 and 1888. The orders for the manufacture of the guns for these first vessels of the new navy were divided between Washington navy yard, the West Point foundry and the South Boston Iron Works. The establishment of the great works of the Bethlehem Iron Co. at South Bethlehem, Pa., and the further enlargement of the works of the Midvale Steel Co., which was the pioneer in the manufacture of gun forgings in the United States, made it clear that no other gun forgings would have to be purchased abroad, and with the exceptions noted, all the guns with which the United States navy is armed are constructed of domestic material and all without exception were made in the United States, and with some modifications upon the same plans originally adopted by the bureau of ordnance.

Many improvements in ordnance have, of course, been made, but the general character of the guns, so far as their construction is concerned, is practically that decided upon in 1878, and the fact that after hundreds of guns of all calibers up to and including 13 in. have been built and placed on naval vessels with no cases of failure in war or in peace, with the exception that the muzzles of one 4-in. and one 5-in. gun were broken off at target practice, affords satisfactory evidence of the wisdom of the navy department in its original adoption of a type of gun and in its adherence thereto. In June, 1887, the first large order for gun forgings and armor was placed by Hon. Wm. C. Whitney, then secretary of the navy, with the Bethlehem Iron Co. (now the Bethlehem Steel Co.), which commenced deliveries of forgings for 6-in. guns in 1888. Since 1883 some 1,400 sets of gun forgings for main battery guns alone have been manufactured in the United States for the navy.

The first modern 6-in. gun for the navy, completed in 1884, weighed 4.8 tons; was 15 ft. in length (that is, 30 calibers), and had a chamber capacity of 1,408 cu. in.; its charge was 45 to 50 lbs. of brown or "cocoa" powder, that being the kind then in use; its projectile weighed 100 lbs. The gun was designed for a maximum chamber pressure of 15 tons per square inch; its muzzle velocity was 2,000 foot-seconds and its corresponding muzzle-energy was 2,773 foot-tons; its power of perforation of wrought iron at the muzzle being 11.19 in. Three separate movements were necessary to open or close the breech of this gun, and it was fitted for percussion firing only. Its rate of fire was one round in one minute, or thereabouts. The gas was checked at the breech end by a plastic pad between two steel disks in front of the breech

plug. It was mounted on a gravity-return mount requiring several men to operate, its recoil being taken up by a hydraulic cylinder under the front end of its mount. Twenty-one guns were made of this type, after which improvements were made in the breech mechanism whereby but two movements were required to open the breech, and the mounts were considerably improved, though the principal features of the original ones were retained.

NO STICKING OF BREECH PLUG.

One hundred and twenty-three 6-in. guns, 30 calibers in length, were made, six of 35 calibers, and sixty-eight of 42 calibers. The latter were essentially of the rapid-firing type, having quick-working breech mechanisms which opened with one movement, and the powder charge being contained in a brass cartridge case, there was no sticking of the breech plug nor fouling of the bore. These guns were fitted for electric and percussion firing, were mounted on pedestal mounts which were capable of being operated by one man, and were supplied with telescopic sights. The guns recoiled in the line of fire and were returned to the firing position by means of spiral springs in the recoil cylinders, which were compressed when the guns recoiled. The 42-caliber gun was 21 ft. 3 in. in length and weighed six tons. With brown powder and a 100-lb. projectile its muzzle velocity was 2,150 foot-seconds and its muzzle energy was 3,204 foot-tons. With smokeless powder, however, the muzzle velocity was raised to 2,550 foot-seconds and the muzzle energy to 4,507 foot-tons, an increase in muzzle energy of 40 per cent., and of 63 per cent. over that of the 30-caliber gun using brown powder.

From the year 1885 to 1900 there was no very marked advance made in our naval guns, except as above stated, and in the details of their mechanisms, but the introduction of slow-burning smokeless powder materially increased their efficiency, as illustrated in the case of the 6-in. gun. In the year 1900, however, new designs were made of United States naval guns of all calibers, whereby they were made considerably longer, heavier and stronger, and with enlarged powder chambers, in consequence of which their energy has been increased in a marked degree.

The latest type of 6-in. gun is 25 ft., or 50 calibers in length, and weighs 8.2 tons. It has a possible rate of fire of nine rounds a minute on the proving ground and a practicable rate of fire of five or six rounds on board ship for a short period. The muzzle velocity of the new gun is 2,900 foot-seconds, and its muzzle energy is 5,836 foot-tons, an increase in muzzle energy over the 30-caliber gun using brown powder of 110 per cent. The chamber capacity of the 50-caliber gun is 245 cu. in. as against 143 in the 30-caliber gun, and the allowed chamber pressure in the new gun is 17 tons per square inch as against 15 tons in the earlier gun. A new 6-in., 50-caliber gun is now being made which is expected to give a muzzle velocity to a 100-lb. projectile of 3,400 foot-seconds.

As an indication of the comparative power of the various types of 6-in. guns, their ability to perforate wrought iron at the muzzle will suffice. The 30-caliber gun at 2,000 f.-s. m. v. will perforate 11.19 in.; the 40-caliber at 2,550 f.-s. m. v., 15.84 in.; the 50-caliber gun at 2,900 f.-s. m. v., 19.04 in., and the 50-caliber gun at 3,400 f.-s. m. v., 23.9 in.

The 6-in. being a gun of medium caliber, and being the intermediate caliber on a number of our most important vessels, is specially referred to; but the 3, 4, 5, 7 and 8-in. guns were all designed and developed on the same principle and are equally efficient. The later guns are perfectly balanced in their slides when loaded, and are mounted on carriages having ball-bearings or frictionless rollers, and can be trained in the vertical and horizontal planes with very great facility. In the later 5 and 6-in. guns the brass cartridge case has been abandoned, as smokeless powder does not foul the chamber of the gun, and the case is not therefore necessary.

HEAVIEST GUNS WEIGH OVER SIXTY TONS.

The heaviest guns now in use or that have been used in our navy are those of 13 in. in caliber, weighing 60½ tons. Such guns are carried by eight of our battleships, each vessel carrying four. The latest vessels to be equipped with such guns are the Alabama, Illinois and Wisconsin. The later battleships, beginning with the new Maine and class and the four harbor defense monitors now about completed, carry guns of 12-in. caliber, and a comparison between them and the earlier guns of the same caliber will illustrate the development which has taken place. The Mark I and Mark II 12-in. guns, of which there are but twelve in service, were manufactured between the years 1892 and 1897. Such guns weigh 45.2 tons and are 36.8 ft. in length, their greatest diameter being 45 in. The powder chamber is 6 ft. 10 in. in length, and its maximum diameter is 14.5 in., and its capacity is 12,043 cu. in. They were designed for a maximum chamber pressure of 15 tons per square inch. With a charge of 425 lbs. of brown powder these guns give a muzzle velocity to an 850-lb. projectile of 2,100 foot-seconds and a muzzle energy of 25,985 foot-tons, having the power to perforate 33.74 in. of wrought iron at the muzzle. The use of smokeless powder in these guns gives them a muzzle velocity of 2,300 foot-seconds with a corresponding muzzle energy of 31,170 foot-tons, with the power to perforate 38.43 inches of wrought iron. The Mark III 12-in. gun, designed in the year 1900, forty-eight of which are assigned to vessels built and building, weighs 52 tons; is 41.6 ft. in length, its greatest diameter being 48½ in.; the powder chamber is 7 ft. 4 in. in length,

its greatest diameter being 16½ in., and its capacity 17,360 cu. in., or 44 per cent. greater than that of the Mark I and II guns. The gun is designed for a maximum chamber pressure of 17 tons per square inch. With a charge of about 360 lbs. of smokeless powder, and a projectile weighing 850 lbs., these guns develop a muzzle velocity of 2,800 foot-seconds, and a corresponding muzzle energy of 46,246 foot-tons, which is 77 per cent. greater than Mark I and II guns using brown powder, and 48 per cent. greater than the same guns using smokeless powder. The Mark III gun has the power to perforate 50.9 in. of wrought iron at the muzzle. Using capped projectiles, Mark I and II guns have the power to perforate 18 in. of hard-faced armor at the muzzle, and the Mark III gun has the power to perforate 23.5 in. under like conditions.

Guns up to and including those of 7 in. in caliber are now built essentially as rapid-firing guns, and the same principle could be applied to those of larger caliber, but the weight of the ammunition and the difficulty of handling it as quickly throws the large guns out of that category.

Among the guns recently designed is one of 7 in. caliber, 45 calibers in length and weighing 13.3 tons. A type of gun has been manufactured, designed to give a muzzle velocity of 2,900 foot-seconds to a 165-lb. projectile within the limits of 17 tons per square inch chamber pressure, and having a muzzle energy of 9,646 foot-tons, with power to perforate at the muzzle, with a capped projectile, 13.2 in. of Krupp armor, and at 2,000 yds. 9.7 in. This gun has been proved to a velocity of 3,035 foot-seconds with a maximum chamber pressure of only 16 1/3 tons, a record which it is believed has not been equaled by any gun of similar class. This gun can readily be fired four times a minute, and similar guns will form the intermediary battery of battleships Connecticut and Louisiana, each vessel carrying twelve.

AMUSING SIDE LIGHTS ON THE SUBJECT.

In view of the extraordinary development that has taken place with respect to ordnance, and the acknowledged endurance of built-up steel guns, it will be interesting to quote from the textbook on gunnery used at the naval academy in 1862, in which we read under the head of "Objections to Breech-Loading Cannon" the following: "In spite of the apparent success of the Armstrong & Whitworth gun, there are objections to breech-loading cannon which must be pointed out, and which go to prove that the endeavor to produce breech-loading cannon is an effort to obtain uncalled for and superfluous facility in gunnery. What superior property can it possess over the solid gun? It cannot be safety; for when we consider the very limited number of explosions by which the very best guns are destroyed, it can scarcely be possible for a gun composed of many parts to endure the intense vibrations to which large cannon are subjected. Vibration, if judiciously distributed, is the soul of endurance, but, if injudiciously distributed, is certain to result in the destruction of the cannon. In structures composed necessarily of many joints, obstructions to the waves of vibration must occur; the different parts do not expand and vibrate equally, a kind of revulsion is induced, part repels part, and destruction ensues as a natural consequence. *Under no circumstances, therefore, can a breech-loading gun be as safe as a solid gun.* The facility of loading and rapidity with which a breech-loading piece can be fired are spoken of as advantages of great importance, but these amount to nothing, for the gun, after every discharge, must be relayed in order to obtain accuracy of aim, and it is the pointing of a gun, and not the loading, that consumes time."

What was then referred to as "superfluous facility in gunnery" is now demanded and is easily accomplished, and instead of time being consumed in pointing time is now consumed in loading, as modern guns, properly mounted, are kept pointed all the time. There are in the navy today some built-up steel guns that have been fired upwards of 1,200 times without showing a sign of weakness, and the only effect of such firing is a slight erosion of the bore, due to the action of the powder gases.

While this country can lay no claim to the origin or early development of the steel built-up rifled guns, now universally adopted, it certainly has contributed in a large measure to their later development, whereby the power of the gun, caliber for caliber, has been enormously increased and its details perfected. The manufacture of gun steel in the United States has been brought to a high state of perfection, and forgings which used to require many months to supply are now turned out in as many weeks. While the gun itself has been developed in a marked degree, its improved ballistics are no less due to the development of the explosives used as propellants, and while it is not intended in this paper to go into a length discussion of the powders now and formerly used, it will not be out of place to refer briefly to them.

Black gunpowder, the oldest of all our explosives, originated in the far east, being used by the Chinese in making fireworks in the seventh century, although the place and date of its origin and the name of its inventor are unknown. The secret of its manufacture was carried by Arab traders to Bagdad, where its adaptability for war purposes was discovered. The army of Genghis Khan first used it in cannon in China in 1234, and the Chinese thus learned its military value. It is generally accepted that it was used at the battle of Crecy in 1346. Western nations probably got their knowledge of it from the Arabs, notwithstanding the stories of its invention by Roger Bacon, and Schwartz, a German monk. Black gunpowder is a mixture of seventy-five

parts of saltpetre or potassium nitrate, fifteen parts of charcoal and ten parts of sulphur. Powder made exactly from the same materials, mixed in the same proportions, differs greatly in its rate of burning, depending chiefly upon its physical properties, namely, density, hardness, shape and size of grain, and the amount of glazing imparted to it. These facts have been known for many years and have been made use of for the purpose of adapting black gunpowder to guns of different class and caliber within the range of its possibilities. Its use for military purposes is now greatly restricted, it being practically used only for filling shell, and as an igniting charge for brown and smokeless powders.

IMPROVEMENT IN THE MANUFACTURE OF GUNPOWDER.

About the year 1883 a modification was made in Germany in the manufacture of gunpowder, and a material called "brown" or "cocoa" powder was produced, so called on account of its color. This powder is composed of seventy-nine parts of saltpetre, eighteen parts of charcoal and three parts of sulphur. The charcoal is made from straw carburized in a special manner, and it is this under-burned straw charcoal which gives this powder its peculiar color. It is pressed into hexagonal prisms, and has the property of producing high velocities with comparatively low pressures, adapting it for use in high powered guns. It has, however, the disadvantage of giving off about 57 per cent. of the products of its combustion in the form of smoke and residue, fouling the bore of the gun and obscuring the vision. It is slow-burning as compared with black gunpowder and requires a priming charge of fine-grain black powder to ignite it properly. It was, however, a great step in advance, and without it it would have been impossible to obtain the high velocities which immediately preceded the higher ones now obtained with smokeless powder. Its cost was about 30 cents a pound, and the average weight of a charge of it was one-half the weight of the projectile; thus a 13-in. gun firing an 1,100-lb. projectile would require a charge of 550 lbs. of brown powder.

Although the production of a satisfactory smokeless powder is a very recent event, the first discoveries in this line date back to the early part of the last century. The word powder is a misnomer as now applied to modern explosives used as propellants, as they are no longer used in powdered form except for small arm ammunition. Such explosives are now used in the form of rods, flat strips, perforated cylinders and hexagonal prisms, and might be used in many other forms. While smokeless powder of various compositions has been in use in foreign navies to some extent during the past ten years, its introduction into the United States navy is of comparatively recent date, the first United States vessel to be fully equipped with such an explosive being the *Marblehead*, in October, 1897. The next vessel was the *Newark*, which was soon after placed in commission, and after her all the new ships as they were completed received an outfit of smokeless powder, as have also all ships coming up for extensive repairs. Guncotton forms the base of our smokeless powder, which for want of a better name we call *pyro-cellulose*, "pyro" being the Greek word for fire and "cellulose" indicating the material of which the powder is made; that is, cotton, which is the form of cellulose best adapted for the purpose. When cotton is dipped in a mixture of nitric and sulphuric acid, washed and dried, it is changed in chemical composition while retaining its original form and appearance. It is, however, converted into a highly combustible explosive substance called "guncotton," which is capable of solution in various liquids. This latter fact is taken advantage of to convert the guncotton from a fibrous mass into a homogeneous body, designated from its glue-like consistency as "colloid." It took about fifty years from the time of the first discovery of guncotton to ascertain that such a colloid possessed the remarkable property of burning progressively under pressure; that is, if formed into regular shapes or grains made up into charges and fired from a gun, the partially consumed fragments blown from the muzzle would retain their original forms in reduced dimensions; and while guncotton itself in its natural state cannot be used in guns as a propellant, being too quick and violent in its action and subject to detonation, it forms, when made into a colloid, a comparatively slow and progressively burning explosive which cannot be detonated, at least as far as we know.

WHAT THE NEW POWDER HAS ACCOMPLISHED.

What the new powder has accomplished may be illustrated by a single example. Within the safety limit of cannon constructed for an internal chamber pressure of 15 tons per square inch, projectiles were formerly propelled with brown powder at a muzzle velocity of about 2,000 ft. per second. Today for the same strain they are propelled from the same guns at a velocity of 2,700 ft. As energy is proportional to the square of the velocity, we find that a projectile moving at 2,700 ft. a second possesses an energy greater than one moving at 2,000 ft. a second, in the ratio of 2,700 squared to 2,000 squared, or as 7.3 is to 4; that is, the new powder has nearly doubled the power or energy to be developed from any given gun, with a considerable less weight of charge. If the same weight of charge was used the ratio would be fairly expressed by 2.5 to 1. The composition and process of manufacture of all navy smokeless powder is the same, but a special size of grain must be made for each caliber of gun, and it can be used with safety for that caliber only. If the grain is too small the powder will be too quick and will get up too high a pressure in the chamber of the gun. If the grain is too large the

powder will be too slow, and while the chamber pressure may be relatively low the maximum pressure will be developed further towards the muzzle of the gun, where it is weaker, to such an extent as to endanger the muzzle of the gun. When guncotton is dissolved in a mixture of ether and alcohol it becomes a plastic mass, and in that condition is forced through dies to give it the desired form. The solvent evaporates rapidly, and the powder soon becomes hard like a piece of stone, but it takes from six to eight weeks to get rid of the solvent to the required extent, though by a process of so-called water-drying the time is greatly reduced.

The Russian and French smokeless powders are very similar in composition to ours, but they use it in flat strips only, while we use ours in the form of short perforated cylinders. The British use a powder made of fifty-eight parts of nitro-glycerine, thirty-seven parts of guncotton and five parts of vaseline, which is called "cordite," because it is made in the form of cords or rods. It is in many respects an excellent explosive, much more powerful than our powder, and requires only about one-half the weight of charge for a given gun as compared with ours, but it is very destructive to the bores of the guns, on account of the great heat evolved during combustion. All smokeless powders, being slow-burning, require a small charge of fine-grained black, or some other quick-burning powder to properly ignite them. This priming charge is attached to the cartridge, and when the latter is inserted in the gun the priming charge is next the primer. The smokeless powder now used in the United States by both the army and navy, was developed at the United States naval torpedo station under the direction of the bureau of ordnance.

IMPROVING THE QUALITY OF PROJECTILES.

The improvement of the gun and the building of armored vessels rendered it necessary that a corresponding improvement should be made in the quality of the projectile, as the vital parts of the modern armored vessels are impervious to attack by cast iron shot or shell. In order to perforate armor great hardness and tenacity are necessary and in consequence the steel armor-piercing projectile was called into existence. When the manufacture of high-power rifled guns was begun in the United States no establishment in the country was able to supply projectiles of suitable quality for use in them, and in consequence a quantity were procured from abroad. It became necessary, of course, that there should be a reliable source of supply in this country, and the bureau of ordnance offered encouragement for private manufacturers to embark in the business. The first concern that took up the subject seriously and successfully was the Carpenter Steel Co. of Reading, Pa., which on May 5, 1890, entered into contract to supply armor-piercing projectiles of various calibers. This company was followed by the Midvale Steel Co. of Philadelphia in January, 1892, and by the Sterling Steel Co. of Pittsburgh in January, 1892, and others later on; and it soon became evident that not only could an abundant supply of armor-piercing projectiles be obtained in this country, but that the quality was fully equal, if not superior, to that of those manufactured abroad.

The most notable improvement in connection with armor-piercing projectiles was the introduction of the Johnson cap on June 21, 1897, that being the date on which the assignment of the patent was made to the government. The Johnson cap is a piece of soft steel securely attached to the point of the projectile, and its use increases the efficiency of the projectile when fired against hard-faced armor from fifteen to twenty per cent. It had been known for some time that if a piece of soft metal was placed in front of and against a face-hardened plate, it would materially aid the projectile in its passage through the plate, and Mr. I. G. Johnson of Spuyten Duyvil, N. Y., taking advantage of this fact, devised a scheme for firmly attaching a soft cap on the point of the projectile, which accomplished the same results. The advantages due to the use of the soft steel cap were fully demonstrated before the right to use it was acquired, and a great number of subsequent tests have confirmed the wisdom of the step, which was taken by the late Rear Admiral Sampson, when chief of the bureau of ordnance.

For a number of years the contracts for armor-piercing projectiles required that when tested the test shells should pass unbroken through a caliber of hard-faced armor; that is, a 10-in. shell should pass unbroken through 10 in. of hard-faced armor, and what were termed "common" shell; that is, steel shell having a capacity for a large bursting charge should pass through half a caliber of hard-faced armor; that is, a 10-in. common shell should pass unbroken through 5 in. of armor, suitable velocities of impact being determined upon for each class. Recently great improvements have been made in projectiles, and shell have been developed embodying the best features of both the armor-piercing and the common; that is, having the ability to carry a large bursting charge through the plate, and the requirements for these shell are that at a prescribed velocity they shall perforate a caliber of hard-faced armor and then be in a condition for effective bursting.

These projectiles were developed by the Firth-Sterling Steel Co. of Pittsburgh and it is believed that they are superior to any projectiles yet made in this country or elsewhere.

The manufacture of armor-piercing projectiles of first-class quality is by no means an easy undertaking, and great credit is due to the American manufacturers for their efforts in this direction; but it may be said that it would have been impracticable

for them to develop them without the co-operation of the bureau of ordnance in furnishing armor plates and guns for the purpose of testing experimental shell. This was necessary, as no private manufacturer could afford such an outlay, and the use of a regular proving ground was also necessary. We have seen, therefore, how modern guns, smokeless powder and armor-piercing projectiles were introduced into the United States navy, and it remains but to show the steps taken to introduce that other important element, namely, armor.

DEVELOPMENT OF ARMOR PLATE.

While in all probability the question of protecting the hulls and crews of vessels of war from the missiles of an enemy had been a subject of serious consideration from very remote periods, the use of heavy plates of metal for such purpose is not of very remote origin. In 1841 Gen. Paixhan, a French officer, who a few years before had revolutionized naval artillery by the introduction of explosive shells in place of the solid shot previously used, recommended the application of iron plates to the sides of vessels for protection against the havoc of his own missiles, and although his plans were rejected by his own government, attention was drawn to the subject of armor for naval vessels. As far back as 1812, John Stevens of Hoboken, N. J., designed a vessel whose battery was protected by inclined armor. This early plan received no serious consideration by any government, but the Stevens family persevered in their investigations and in 1842 Robert L. Stevens, a member of the same family, submitted to a committee of congress on coast defenses a report in which he published certain deductions concerning the laws of penetration of projectiles into iron armor, drawn from a long series of experiments. He also submitted a design of an iron clad vessel, but the matter proceeded no further until the spring of 1854, when appropriation was made to build the ship, this action being taken a few months earlier than the commencement of the first ironclad in Europe. The Stevens' battery was never completed, however; it remained in the same state in which it was left at the death of Robert L. Stevens in 1856 until after the death of Edwin A. Stevens in 1868. The latter bequeathed it to the state of New Jersey, together with the sum of \$1,000,000 for its completion. This money was spent in 1869 and 1870, but the vessel was not launched, and in 1881 was broken up and sold as old material.

About two months after the laying of the keel of the Stevens' battery, the French government began the construction of the iron clad floating batteries *Devastation*, *Lave*, *Touante* and *Congreve* at Toulon, and a few months later the English commenced the construction of the iron clad vessels *Erebus*, *Terrible* and *Thunderer*. On Oct. 17, 1855, the French batteries just referred to, with the exception of the *Congreve*, forming the first iron clad squadron ever seen, engaged the Kinburn forts in the Crimea, which had held at bay the combined fleets of France and England, silencing them in four hours. These floating batteries were of about 1,600 tons displacement, and had a speed of scant 4 knots. Their armor consisted of 4½-in. solid plates backed by 27 in. of oak, and their batteries were composed of sixteen guns corresponding to 68-pounders. They took positions of from 870 to 1,100 yds. off the main fort, which was armed with guns corresponding to 32-pounders. The *Devastation* was hit sixty-four times and the *Touante* sixty-five times, but their armor was but little injured, the penetration being only about 1½ in.

DISPUTES MONITOR'S INFLUENCE ON ARMOR CLAD DEVELOPMENT.

Many are of the opinion that the engagement at Hampton Roads in March, 1862, between the confederate iron clad *Merrimac* and the United States frigates *Congress* and *Cumberland*, and with the *Monitor*, were the prime cause which led to the adoption of armored ships, but such is not the case, though it may, and no doubt did, have an important effect upon subsequent naval construction. It was the introduction of guns of greater energy, having longer range and greater accuracy than the smooth-bore guns, that rendered the use of armor a necessity, and prior to the conflicts in Hampton Roads, both England and France had each constructed a squadron of iron clad floating batteries. In 1858 the first squadron of sea-going iron clad frigates, the *Gloire*, *Normandie*, *Invincible* and *Couronne*, was commenced in France, and they were quickly followed in England by the *Warrior*, *Black Prince*, *Defense* and *Resistance*.

The first sea-going iron clad that appeared was the *Gloire*, in 1859, armed with rifled guns, and her performance on the ocean left no further doubt as to the sea-going qualities of which such vessels were capable, and from that time it was undeniable that armored ships must form at least a part of all navies. That this fact was generally accepted by all the principal maritime nations of the world except the United States, is evidenced by the fact that before the United States congress had considered the question of iron clads, England, France, Spain, Italy, Austria, Denmark and the southern confederacy either had iron clads afloat or on the stocks, and before Ericsson had submitted the design of the *Monitor* to the naval commission, Capt. Cowper Coles had demonstrated the advantages of the turret, mounted on low freeboard iron clad hulls, in public to the naval experts of England. Before the United States had closed the contract with Ericsson for the *Monitor*, the Danes had made one with Coles for the double-turreted sea-going iron clad *Rolf Krake*, and her keel was laid before the *Monitor* was authorized. In 1859 the

French built an iron clad vessel in thirty-seven days from the laying of the keel.

At the extra session of congress which convened on July 4, 1861, pursuant to the proclamation of President Lincoln, a report was submitted by Gideon Wells, secretary of the navy, in which he adverted to the fact that other governments were constructing armored vessels, and he recommended that initiatory measures should be taken by our government for the construction of "one or more iron clad steamers or floating batteries." Congress responded promptly and liberally to this recommendation, and on Aug. 3, 1861, passed an act authorizing and directing the secretary of the navy to appoint a board of three skillful naval officers to investigate the plans and specifications that might be submitted for the construction or completion of iron or steel-clad steamships or steam batteries, appropriating the sum of \$1,500,000 for the construction of one or more of the same should the plans be approved. On Aug. 7, or four days after the passage of the act above referred to, the navy department issued an advertisement "for the construction of one or more iron clad steam vessels of war, either of iron or of wood and iron combined, for sea or river service; to be of not less than 10 or more than 16-ft. draught of water; to carry an armament of from 80 to 120 tons weight, with provisions and stores for from 165 to 300 persons, according to armament, for sixty days, with coal for eight days. The vessels to be rigged with two masts, with wire rope standing rigging, to navigate at sea. Propositions to be received for twenty-five days."

On the following day (Aug. 8, 1861) the secretary of the navy appointed a board composed of Commodore Joseph Smith, U. S. N.; Commodore Hiram Paulding, U. S. N., and Captain Charles H. Davis, U. S. N., to consider such plans as might be received.

HOW THE MONITOR CAME TO BE BUILT.

In September, 1861, Mr. C. S. Bushnell of New Haven brought to the notice of Secretary Wells, Capt. John Ericsson's plans of the original *Monitor*. Mr. Wells was so favorably impressed with them that he suggested that Mr. Bushnell should proceed to Washington and exhibit them to the board, upon which suggestion Mr. Bushnell at once acted. On Sept. 16, 1861, the board submitted its report, which embraced the plans presented by seventeen bidders. Three propositions were favorably considered, namely those of John Ericsson of New York, C. S. Bushnell & Co. of New Haven and Merrick & Sons of Philadelphia. With regard to Ericsson's design the board remarks: "This plan of a floating battery is novel, but seems to be based upon a plan that will render the battery shot and shell proof. We are somewhat apprehensive that her properties for sea are not such as a sea-going vessel should possess, but she may be moved from one place to another on the coast in smooth water. We recommend that an experiment be made with one battery of this description on the terms proposed, with a guarantee and forfeiture in case of failure in any of the properties and points of the vessel as proposed." On Oct. 4, 1861, the navy department entered into contract with Capt. Ericsson for a vessel on his plan, which was described as "an iron clad, shot-proof steam battery of iron and wood combined." Her dimensions, etc., were: Length, 172 ft.; breadth, 41 ft.; depth of hold, 11½ ft.; draught of water, 10 ft.; displacement, 1,255 tons; speed, 9 statute miles per hour; time of completion, 100 days; contract price, \$275,000. The *Monitor* was completed within the time specified, and sailed from New York for Hampton Roads on Mar. 6, 1862, reaching the latter on Mar. 8, and on the following day had her memorable encounter with the confederate iron clad steamer *Merrimac*. This, then, was the first iron clad vessel built for the United States government, and, aside from the novelty of her design, did not represent by a long way the development which had taken place abroad in armored ships. Her deck, sides and turret were protected with iron plates—about one inch thick—built up in layers, and her armament consisted of two 11-in. cast iron, smooth-bore guns.

When we contrast our first iron clad of 1,255 tons displacement and 9 knots speed, built in 1861, with the sea-going battleship *Louisiana* of 16,000 tons displacement and 18 knots speed, carrying 3,947 tons of material for protection only, and an armament with its ammunition weighing 1,536 tons, it conveys some idea of the progress of development of ships of war.

It may be safely asserted that prior to 1854 the manufacture of armor plate had not become a distinct industry. Between the years 1854 and 1858 the manufacture of solid armor plates was limited to those of a thickness of 4½ in., and it was not until 1859 that any marked advance became apparent.

The history of the development of armor shows the vast amount of time and money expended in the effort to produce novel types of superior resisting power that would effect a saving in weight and in cost. During these investigations target structures of almost every conceivable description were made and subjected to ballistic test. There were homogeneous cast iron and wrought iron plates, and built-up targets of every description, including sheets of metal bolted together and presented flat or edgewise; alternating layers of metal and wood; of metal and rubber disposed in various ways, and of springs behind solid plates and between the laminations of built-up plates. The targets were fired at vertically and inclined at various angles. The result of all these experiments, most of which were made abroad, was the general adoption in the period just prior to the civil war

of homogeneous wrought iron for armor, the plates being secured vertically to the sides of the vessel and attached rigidly to wooden backing. The outbreak of the civil war not only found the United States government without any armor clad vessels, but with no facilities in the country for making anything but very thin plates, and it was therefore forced to make use of such material for the protection of vessels built at that period. The United States Navy Register of 1864 contains among the list of vessels of the navy the names of seventy-three "iron clads," showing that the use of armored protection for vessels of war, even though of an inferior quality, was recognized as an essential feature of their construction at that period. The list consisted of the double and single-turreted monitors, several of which remain in the navy today, though the vessels themselves are of but little military value, having obsolete guns and very inferior armor; of the so-called light-draught monitors, which proved to be utter failures, and of which none happily remain, and of a number of Mississippi river steamers which had been adapted for military purposes, and a few of more notable type, namely, the Dunderberg, New Ironsides, Galena and Keokuk. The same publication contains a list of United States iron clads which had disappeared from service during the civil war, namely, the Cairo, sunk by a torpedo in Yazoo river on Dec. 12, 1862, the original Monitor, foundered off Cape Hatteras Dec. 31, 1862, the Indianola, captured in the Mississippi river Feb. 24, 1863, the Cincinnati, sunk by the batteries at Vicksburg May 27, 1863, and raised in the following August, the Baron de Kalb, sunk by a torpedo in the Yazoo river July, 1863, the Keokuk, sunk by gun fire off Charleston, S. C., April 7, 1863, the Weehauken, sunk off Charleston, S. C., Dec. 6, 1863, and afterwards raised, the Eastport, destroyed in Red river to escape capture April 26, 1864, the Tecumseh, sunk by a torpedo in Mobile bay Aug. 5, 1864, and the Patapsco, sunk by a torpedo in Charleston harbor Jan. 15, 1865. The armor of nearly all of the United States vessels of this period consisted of several layers of thin plates, each about 1 in. thick, laid on a heavy wooden backing, and while of a very inferior quality as viewed from the present standpoint of efficiency, it proved to be quite effective against the artillery then opposed to it. The old monitors received many hits off Charleston, some of the records being as follows: Montauk, hit 214 times; Weehauken, 187 times; Patapsco, 144 times; Passaic, 134 times; Catskill, 106 times; Nahant, 105 times; Nantucket, 104 times; Lehigh, 36 times, and the New Ironsides, 193 times. Many of these hits were from 10-in. Columbiads, and though the vessels as a rule were able to remain at their stations, they suffered considerable injury, though but little was said about it at the time.

SOME OF THE EARLY IRON CLADS.

The most notable United States iron clads at that period were the Dunderberg and the New Ironsides, and a few words concerning them may not be without interest.

The Dunderberg (or Thundering Mountain) was built by Wm. H. Webb of New York at New York and is described in the official papers as "an iron clad, shot-proof, steam screw ship of war with ram, to be built of wood and cased with iron." It was designed to carry two revolving gun turrets on the casemate deck, each to be not less than 21 ft. in diameter and 8 ft. high in the clear, the armor iron of which not to be less than 11 in. thick; each turret to contain two guns of 15-in. caliber, and in the casemate eight 11-in. Dahlgren guns were to be carried. There was to be a "shot-proof pilot house" on one of the turrets or on the casemate deck. The engines and boilers were to be "of sufficient capacity to propel the vessel at least 15 knots per hour for twelve consecutive hours in fair weather and smooth water at sea;" the engines to be of the low-pressure condensing type; the turrets to be turned by steam; the vessel to be completed in fifteen months from July 3, 1862; the guns to be supplied by the government, but the contractors to furnish the gun carriages; contract price, \$1,250,000 in twenty-five payments of \$50,000 each; the port shutters to be of wrought iron $4\frac{1}{2}$ in. thick; the outer hull to be of wood 6 ft. thick at the main deck level, decreasing to 2 in. at the bilge; the underwater body to be coppered; the sides of the vessels from the main deck to about 5 ft. below the load-water line to be covered with iron $3\frac{1}{2}$ in. thick from deck to water line and then tapering to $2\frac{1}{2}$ in. at the lower edge, and also tapering towards the bow and stern to $2\frac{1}{2}$ in., made in slabs placed vertically. The sloping sides and ends of the casemate were to be covered with iron plates $4\frac{1}{2}$ in. thick, made in one thickness, and not less than 28 in. wide, or wider if they could be manufactured. The following details regarding the ship and her machinery, show her to have been an unusually huge craft for her day: Extreme length, 380 ft. 4 in.; extreme breadth, 72 ft. 10 in.; depth of main hold, 22 ft. 7 in.; height of casemate, 7 ft. 9 in.; length of ram, 50 ft.; draught, ready for sea, 21 ft.; displacement, 7,000 tons; tonnage, 5,000; weight of iron armor, 1,000 tons; diameter of steam cylinders (2), 100 in.; stroke of piston, 45 in.; boilers, six main and two auxiliary; height of boilers, 17 ft. 6 in.; front width of boilers, 21 ft. 5 in.; weight of boilers, 450 tons; total heating surface, 30,000 sq. ft.; total grate surface, 1,200 sq. ft.; cooling surface in condensers, 12,000 sq. ft.; diameter of screw propeller, 21 ft.; pitch of screw propeller, 27 to 30 ft.; weight of screw propeller, 34,580 lbs.; capacity of coal bunkers, 1,000 tons; indicated horse power, 5,000; smoke stack, 13 ft. diameter with armored gratings; engines, horizontal, back-acting, de-

signed to run at sixty revolutions per minute at ordinary and at eighty at full speed; main shaft, 118 ft. long by 18 in. diameter.

HOW THE ARMAMENT WAS DISTRIBUTED.

The armament as projected was probably more than the ship could carry, and it was finally decided to omit the turrets and the turret guns, and to give the vessel two 15 and four 11-in. guns; one 15 and one 11-in. to be mounted on each broadside and one 11-in. at each end of the casemate. This battery was mounted about February, 1867, from which it will appear that instead of being completed in October, 1863, as required by the contract, the vessel was not completed until three and a half years later. On Feb. 22, 1867, the Dunderberg went to sea to test her battery, and its general performance was reported as satisfactory. On account of the omission of the turrets a deduction of \$22,860 was made from the contract price. It does not appear that a regular speed trial was made, but it is recorded that at one time a speed of 10 knots was attained with forty-one revolutions of the screw, with a boiler pressure of 17 lbs. per square inch. After the vessel was completed she was by authority of congress turned over to the builders upon payment by them of all moneys paid or advanced by the government, and under the terms of the act of Mar. 2, 1867, Mr. Webb had to pay back to the United States treasury the sum of \$1,041,666.68, which had been paid him on account, and on June 27, 1867, he paid into the treasury in cash, checks, etc., the sum of \$1,092,887.73, the difference being for articles of equipment and for two 15-in. guns, ammunition, etc., purchased by him for the ship from the government. The ship was then sold by him to the French government, and after some alterations was put in the service of the French navy under the name of Rochambeau. There are no records available showing the nature of these alterations or her later history.

The New Ironsides was designed and built by the Cramp company of Philadelphia, but the scheme of the vessel was due to Mr. B. H. Bartol of the Philadelphia engine-building firm of Merrick & Co. She was called a casemated, iron clad frigate, with unarmored ends, except that her water line was protected by a complete belt. Her battery consisted of fourteen 11-in. smooth-bores and two 8-in. Parrott rifles, mounted in a casemate. Her speed was about 6 knots, as she was supplied with the machinery that had been built for a corvette of the Wyoming class; she had, however, a good spread of sail in addition. Her armor consisted of $4\frac{1}{2}$ -in. solid iron plates, backed by 21 in. of oak, the inclination of the casemate being 30° from the perpendicular. The armor plates were manufactured at Pittsburg. For two years this ship was subjected to the most severe test a war vessel can undergo—alternate blockade duty and close action against fortifications. On one occasion she remained in action three hours alone against the combined forts of Charleston harbor, holding down the artillery fire of the batteries until she was obliged to haul out for lack of ammunition. During this time she was struck on her side armor sixty times, but an investigation showed her to be entirely uninjured. In a period of about six months the New Ironsides was struck 193 times, and was never forced to leave the station for repairs. After the civil war this vessel was laid up at League Island, Philadelphia, and was destroyed by an accidental fire.

OLD CONFEDERATE IRON CLADS EXCITE ADMIRATION.

The confederate iron clad steamers Merrimac, Atlanta and Tennessee are well worthy of mention, as when we consider the limited means at hand and the lack of skilled labor available, the results achieved cannot but excite the admiration of naval people. As is well known the Merrimac, or Virginia as she was officially known, was the United States frigate Merrimac, which fell into the hands of the confederacy at the Norfolk navy yard when it was abandoned by the United States forces. She was cut down and a heavy casemate of timber was built upon her, which was covered with two layers of narrow bars of rolled iron, each $1\frac{1}{2}$ inches thick, making a total of 3 inches. These slabs were rolled from railroad iron and were therefore of excellent material. This iron plating was laid over 20 in. of oak, and was placed at an angle of about 30° from the horizontal. So far as known no material damage was done to the armor of the Merrimac by the fire of the Cumberland, Congress or Monitor.

The Confederate steamer Atlanta was built by converting an iron-hulled blockade-running steamer called the Fingal. Additional displacement was given her by sponsoning her out with square logs, thus increasing her beam, and she was fitted with a central casemate or citadel built of 15 in. of Georgia pine covered by 3 in. of oak, on which were laid two courses of 2-in. iron bars, 7 in. wide (probably rolled from railroad iron), the inner layer being horizontal and the outer one vertical, the fastenings being $1\frac{1}{4}$ -in. through bolts set up with nuts and washers. She had a battery of two 6-in. and two 7-in. rifles. The sides of the casemate were inclined at an angle of about 30° from the horizontal. The Atlanta, under the command of Capt. Wm. A. Webb of the Confederate navy, was captured by the U. S. Monitor Weehauken, Capt. John Rodgers, on July 17, 1863, in the sounds of North Carolina. The Weehauken fired five shots, three of which took effect, penetrating the Atlanta's armor, and killing or wounding many of the crew of two guns; she was struck by two 15-in. and one 11-in. shot, and grounded and surrendered.

The Tennessee was after the same type as the Atlanta, but was built of wood and specially constructed for use as a vessel of war, and was therefore somewhat heavier. The framing of the casemate consisted of an inside diagonal ceiling of 2½-in. oak, vertical pine timbers 13 in. thick, yellow pine planking 5½ in. thick, an outside layer of 4 in. of oak timber covered by three thicknesses of 2-in. iron bars, 7 in. wide; the whole fastened by 1½-in. through bolts set up with nuts on the inside. The armor of the ends of the casemate was 1 in. less in thickness. At the battle of Mobile bay a 15-in. shot from one of the monitors smashed in the port side of the Tennessee's casemate, though the shot itself did not get through. She was struck many times and suffered much injury.

From the vessels above described to the steel-clad floating fortresses of today was a gigantic stride, though the time required for its accomplishment was by no means great.

ARMORED VESSELS OF THE MODERN NAVY.

The first of the armored vessels of the modern navy were the Maine and Texas, authorized by the act of Mar. 3, 1886, which act also provided for the reconstruction of the monitors Puritan, Monadnock, Amphitrite and Terror. This authorization was followed by the issue of a circular by the navy department, dated Aug. 21, 1886, inviting bids for armor-plate and gun-steel of domestic manufacture; and the consideration of the manufacture of modern armor in the United States may be said to date from the issue of this circular. The bids received under this advertisement were opened on Mar. 22, 1887, proposals being received from the Bethlehem Iron Co. for both; from the Cambria Iron Co. of Johnstown, Pa., and from the Midvale Steel Co. of Philadelphia for gun-steel only, and from the Cambria Rolling Mill Co. of Johnstown, Pa., for armor plates only. The bid of the Bethlehem Iron Co. being the only one for both kinds of material, and being in the aggregate the lowest, was accepted, and a contract was made with that company on June 1, 1887, for both armor and gun-steel. This contract included armor for the second-class battleships Maine and Texas, and for monitors Puritan, Monadnock, Amphitrite and Terror. The amount of armor contracted for was estimated at about 6,700 tons, and was to be of plain steel, oil-tempered and annealed, but prior to the first deliveries, which were made in the fall of 1891, radical changes were made in the specifications, and the introduction of nickel and the use of re-forging and face-hardening processes were included.

About the year 1888 a sufficient quantity of armor was ordered from England for the Monitor Miantonomoh; this armor being of the type known as "compound armor," its cost being \$535 per ton.

INTRODUCTION OF NICKEL INTO STEEL.

Prior to the date of the circular above referred to numerous experiments had been made in England, Russia, Italy, France and Germany of various types of armor, and from 1882 to 1887 the contest for superiority lay between the compound and the all-steel plates, English manufacturers presenting the former, while Messrs. Schneider of France were the chief advocates of the latter. Compound armor generally resisted penetration better than the all-steel plate, because it was possible to make the thin steel face of the former much harder than that of the all-steel plate, without sacrificing the toughness necessary to prevent breaking up. The chief failure of the compound plate was in the flaking off of the steel face from its iron back. This led to a continued effort to produce all-steel plates that would present a hard face and still retain sufficient toughness. By the introduction, in 1889, of a small percentage of nickel in the manufacture of steel, unusual toughness was produced. Such was the armor situation when the United States government commenced the building of armored vessels for its new navy, and while, as previously stated, the armor ordered for the first of the new vessels was of plain steel, it gave place to that containing nickel, as the result of the first important armor test made in the United States at the Annapolis proving ground in September, 1890, this test being made principally to determine the respective value of plain steel, of nickel steel, and of compound armor plates. To carry out this experiment three plates of equal dimensions were procured, namely, 8 ft. by 6 ft. by 10½ in. and were subjected to similar attacks. The plates tested consisted of a compound plate made by Cammel & Co. of England, a plain steel plate made by Schneider & Co. of France, and a nickel steel plate also made by the latter. All three plates were subjected to five impacts, four by a 100-lb. armor-piercing projectile fired from a 6-in. gun, with a striking velocity of 2,075 foot-seconds, one shot being directed at each corner of the plates, and a fifth impact by a 210-lb. projectile, fired from an 8-in. gun, with a striking velocity of 1,850 foot-seconds, at the center of the plates. All three plates were supported by 36-in. of oak backing. The compound plate was perforated by all the shell, and was practically destroyed by the 6-in. alone. The plain-steel plate kept out all the shell, but was badly cracked by the 8-in. The nickel-steel plate kept out all the shell, and remained without cracks. After these tests it was decided to use nickel-steel for the armor of United States vessels, and the navy de-

partment took immediate steps to procure a large supply of nickel-matter for such purpose.

Probably no step in the development of modern armor is more interesting or was of greater importance than was the introduction of the Harvey process of face-hardening, originated by Mr. Hayward Augustus Harvey, who was born at Jamestown, New York, Jan. 17, 1824. At the time he conceived the idea of face-hardening steel plates (1889) he was president of the Harvey Steel Co. of Newark, N. J. During that year he treated a block of steel with a view to giving it a very hard face and great power of resistance, and was so successful that he brought his experiments to the attention of the navy department, which at his request furnished him a small plate 6 in. in thickness, which was treated at the company's works in Newark; was face-hardened at the Washington navy yard under Mr. Harvey's directions, and was tested at the naval proving ground at Annapolis in 1890. This plate was made by the Linden Steel Co. of Pittsburg and was cut in halves, and one-half was treated by the Harvey process and the other half left untreated. When tested the treated part showed such superior qualities of resistance over the untreated half that the navy department decided to experiment on a larger scale, and therefore procured from Messrs. Schneider & Co. of Le Creusot, France, a steel plate 10½ in. in thickness for the purpose, there being at that time no facilities in this country for the manufacture of such plates. This plate was treated at the Washington navy yard in January, 1891, in a furnace especially erected for the purpose, under the direction of Mr. Harvey, in which the process of super-carburization was performed. The bed of the furnace being first covered with sand a few inches thick, the plate was laid thereon in a horizontal position, and its upper face, which was to be treated, was covered with a layer of carburizing material, probably a mixture of animal and vegetable charcoal, about 1 ft. thick, over which was laid a covering of tiles to exclude the flame and air from the plate. The doors of the furnace were bricked up and the fires were started, and it was brought up to a high degree of heat, which was maintained for about one hundred hours. Much difficulty was experienced in getting the heated plate out of the furnace, and a period of five hours was consumed for this purpose, as the arrangements were very crude. When the plate was finally free from the furnace and was hauled under the sprinkling trough, it was of a dull cherry red color, and in this condition was heavily sprayed on one side with jets of cold water, which fell several feet from the trough above. The cooled surface naturally contracted and distorted the plate, which curled up like a saucer under the influence of the chill. The spraving was continued until the plate was cooled to black heat, when it recovered its shape somewhat, but the warping was then regarded as a serious objection to the process, but in future plates this was overcome by spraying the heated plates on both sides; and in the regular furnaces thereafter constructed the plates were laid on iron cars and could then be readily removed. The writer of this article was then in charge of the naval gun factory, and thus had charge of this interesting experiment which was to cause so great a revolution in the character of the armored protection of ships of war of all nations.

TEST OF HARVEYZED PLATES.

This imperfectly treated plate was tested at the Indian Head proving ground in February, 1891, being attacked by seven 6-in. projectiles of 100 lbs. weight, having a striking velocity of 2,065 foot-seconds. The greatest penetration was 4 in., except in one round, that at the center of the plate, when the point of the shell reached the backing. All the projectiles were broken up. The plate was cracked, but until the last round no part of it was detached from the backing. At this round about one-eighth of the plate fell to the ground. These results were considered remarkable, and it was concluded that by means of this method of treatment, armor of ideal quality—that is, having a very hard face combined with a tough back, without any weld or other line of demarcation between them—could be made. The navy department, therefore, decided to hold a further series of armor trials in which the relative merits of plain and nickel steel of domestic manufacture, when treated by the Harvey process, should be submitted to exhaustive competition. Accordingly, eight plates, each of 6 ft. by 8 ft. by 10½ in. were ordered—five from Carnegie, Phipps & Co. and three from the Bethlehem Iron Co. The tests of these plates took place at Indian Head, Maryland, on Oct. 31 and Nov. 14, 1891, but only six plates were fired at, as two of those furnished by Carnegie, Phipps & Co. were withdrawn on account of defects in manufacture. Each plate received four impacts from 6-in. shell, one at each corner, and one 8-in. shell in the center. The 6-in. shell weighed 100 lbs. and were fired to give a striking velocity of 2,075 foot-seconds. The 8-in. shell weighed 210 and 250 lbs., respectively, and were fired to give striking velocities of 1,850 and 1,700 foot-seconds, the energy being the same in either case. The three Bethlehem plates used were, respectively, a high-carbon nickel-steel, a medium-carbon nickel-steel Harveyed, and a plain steel Harveyed. The three Carnegie, Phipps & Co. plates were, respectively, a high-carbon nickel-steel, a low-carbon nickel-steel, and a low-carbon nickel-steel Harveyed. All the plates showed greater resistance to penetration and less cracking than did the English compound plate of the previous year. Two of the plates showed greater resistance to perforation and less cracking than did the most resisting plate at the An-

napolis test of the previous year. The results given by the nickel-steel plate tested by the Harvey process, manufactured by the Bethlehem Iron Co., were considered the most satisfactory, and the conclusion was reached that two important results had been achieved—first, a better plate of American manufacture had been produced than the department was able to purchase abroad the year previous; secondly, the development of a new principle in the manufacture of armor of American origin, which there were good grounds for believing would furnish greater protection to the vital parts of a vessel of war than any other system hitherto employed.

While the foregoing tests were considered very conclusive, the navy department decided to make still another before finally adopting the Harvey process, and in the latter part of 1891 two more 10½-in. nickel-steel plates were ordered from the Bethlehem Iron Co., both of which were treated by the Harvey process and tempered by an improved method. These two plates differed in one respect, namely, the first having been forged to 12½ in., and, after supercarburization, being further reduced by forging to 10½ in.; the second being forged to final dimensions—that is, to 10½ in. before Harveyizing. The chemical and physical properties of the plates before treatment were the same. These plates were tested at Indian Head on July 23, 1892, under precisely the same conditions as those of October and November, 1891, and established not only the value of the Harvey process, but also that of retreating after supercarburization, and it was determined that thereafter all armor for the navy should be so treated.

DEVELOPMENT OF KRUPP PROCESS.

Improvements in manufacture followed from time to time, and the so-called Harveyed plates held the lead in all countries until a modification thereof was made at the works of Herr Krupp, in Germany, 1895. The first important mention of the new Krupp process dates from the test of an 11.8-in. plate at the company's proving ground at Meppen on Sept. 15, 1895. From published statements this plate showed unusually good ballistic qualities and such immunity from cracking that it was referred to as the champion thick experimental plate. The principal English manufacturers acquired the process, and in 1897 Messrs. Vickers, Sons & Co. presented for official test an 11 11/16 in. and a 6-in. plate, both of which gave excellent results and fully bore out the reputation which the new Krupp process had attained in Germany. Other British manufacturers presented plates made by the new process, and the superiority of such armor was so fully established that its adoption became an assured fact, it being merely a question of the ability of the manufacturers to produce it, as its manufacture necessitated extensive alterations to the then existing armor plants. The American armor manufacturers having acquired the rights to use the new process, submitted in July, 1898, the first Krupp plate manufactured in this country, the credit for so doing belonging to the Carnegie Steel Co., and in October of the same year the Bethlehem Steel Co. also submitted an experimental plate, both companies following with second plates. The tests of these plates showed their excellence, and also that the American manufacturers could produce armor by the new process equal to that made abroad. The Krupp process is in fact an improvement on the Harvey process, and the alloy used is referred to as nickel-chrome, as both of these metals enter into its composition; and the process of supercarburization in the case of the Krupp plates is produced by means of a hydro-carbon gas instead of by means of a solid carbonizing material, as was the case with the Harvey process. Krupp plates are not only tougher and more resisting than Harveyed plates, but they have the peculiarity of not cracking under heavy impacts, which is a matter of great moment. The superiority of armor plates manufactured by the Krupp process is more apparent in the case of thick plates than in thin ones, and it is an open question whether in plates of not over 5 in. in thickness the Harveyed plates are not equally as good. The armored ships now building and those about to be commenced will all carry Krupp armor for all plates over 5 in. in thickness, and possibly for some of the thinner plates.

TROUBLE OVER COST OF ARMOR PLATE.

For a number of years the cost of armor plate was under discussion by both houses of congress, and various restrictions were imposed, which led to many complications and delays in the completion of vessels under contract, but the act of June 7, 1900, provided "that the secretary of the navy is hereby authorized to procure by contract armor of the best quality for any or all vessels above referred to, provided such contracts can be made at a price which in his judgment is reasonable and equitable, but in case he is unable to make contracts for armor under the above conditions, he is hereby authorized and directed to procure a site for and to erect thereon a factory for the manufacture of armor, and the sum of \$4,000,000 is hereby appropriated towards the erection of said factory." Under these provisions the secretary of the navy, after public advertisement and prolonged negotiations, made contracts for 37,184 tons of armor, more or less, covering all the armor required for vessels authorized for which no provision had been previously made. The amount of armor previously ordered amounted to 35,773 tons, so that the total quantity of armor ordered for the ships of the new navy since July 1, 1887, amounts to 72,957 tons.

ADMIRAL O'NEIL'S PAPER DISCUSSED.

Prof. Hovgaard of the Massachusetts Institute of Technology was inclined to take issue with the statement of the admiral that the adoption of armor was determined by the creation of guns of greater energy. He was inclined to the belief that the necessity for armor was determined by the invention of the explosive shell.

Mr. W. D. Forbes supplemented the data contained in Admiral O'Neil's paper by information regarding the early manufacture of cannon in America which he had lately run across. He said: "At Lynn, Mass., 1647, the first cannon was cast in this country. In 1648 the first brass cannon was cast in Bridgewater by the Orr foundry. In 1775 18-pounders seemed to be the largest guns cast and this size was made at the rate of one a day by Daniel Joy in Reading, Pa. At this time a man by the name of Clapp got up a machine for boring cannon and the committee of safety of Massachusetts agreed to buy it if Mr. Orr, before referred to, considered it good. In 1794 Gen. Knox, secretary of war, contracted with the Hope furnace for 32-pounders for \$106.66 per ton. In 1795 Secretary of War Pickering contracted for cannon at the following prices: 32-pounders, \$420 each; 24-pounders, \$350; 18-pounders, \$318; 12-pounders, \$211; 9-pounders, \$140; 6-pounders, \$130. In 1790 Wm. Deming made cannon of wrought iron staves linked with iron. One of these is now in the tower of London. This is the first built-up gun I find record of. In 1818 Col. Bomford of the ordnance corps contracted with R. L. Stevens for elongated shells made of a secret process. In 1812 the bureau of ordnance was established. In 1811 the committee of congress reported: 'The foundries in Rhode Island, Pennsylvania and other states have arrived at perfection in the art of boring cannon, it being so well understood that our inspector of artillery has declared to the board that he never was compelled to reject a single gun on account of defect in the bore, although he had examined over 2,000 cannon.' From this it would seem that we have not only made progress in the art of building guns but also in inspectors."

Col. Stevens called the attention of the society to the fact that he had in his possession one of the old brass 6-pounders, made in Strassburg in 1761 and brought to this country during the revolution.

REAR ADMIRAL FRANCIS T. BOWLES.

Rear Admiral Francis T. Bowles was appointed cadet engineer Sept. 15, 1875. Later he resigned and was commissioned assistant naval constructor on Nov. 1, 1881. His resignation was due to the fact that the law requires that an officer in this corps must be appointed from civil life. He was commissioned naval constructor on Oct. 10, 1888. Bowles was in charge of the construction work at the Norfolk yard just before and at the time of the building of the Raleigh and Texas. William C. Whitney, who was the secretary of the navy at that time, had purchased the designs of the Texas from an Englishman. The designs were bitterly attacked but Bowles



Rear Admiral Francis T. Bowles.

staked his professional reputation upon their success and after two boards had passed upon them construction proceeded. The Texas is a success. He was a member of the naval advisory board that designed the steel cruisers Chicago, Boston, Atlanta and Dolphin, and it is generally believed that the principal credit for their really excellent design and arrangement of battery belongs to him. The Chicago is generally considered the most seaworthy and comfortable cruiser in the service. Admiral Bowles was made chief constructor of the navy in 1901. He is one of the few American officers who had the privilege of passing through the course of naval architecture at the Royal Naval College of the British government.

REMARKS ON THE NEW DESIGNS FOR NAVAL VESSELS.

Rear Admiral Francis T. Bowles, chief constructor of the United States navy, then read his paper upon the subject, "Remarks on the New Designs for Naval Vessels." His paper was upon the new battleships Connecticut and Louisiana and the armored cruisers Washington and Tennessee and he was liberally applauded when he had done reading it. The paper was brief and is as follows:

In the preparation of the recent designs for the battleships of the Connecticut class and the armored cruisers of the Tennessee class, consideration has been given to matters affecting the time required for completion. Up to the present ten battleships for the navy have been built and completed by contractors, and the average time required from the date of the contract until the date of the first commission has been four years and eight months, varying from a minimum of four years and one month to a maximum of five years and eight months. These periods are too great and disadvantageous both to the government and to the contractor, as the government fails to obtain the use of its property, and the cost of construction is undoubtedly increased. The causes of the delays which have occurred in the construction of naval vessels are numerous and need not be recited here. The one conspicuous cause which it was possible for the government to remedy has been taken in hand in these designs and it is hoped eliminated. The contract plans now issued to the contractor, as shown in the annexed list, are very complete so far as all general features of the structure and arrangements of the vessel are concerned. The specifications have been arranged in a logical order, and have been made in all particulars definite and conclusive, instead of leaving many items of importance to the vessel and involving a large element of cost to the discretion of the superintending naval constructor, or "as may be required."

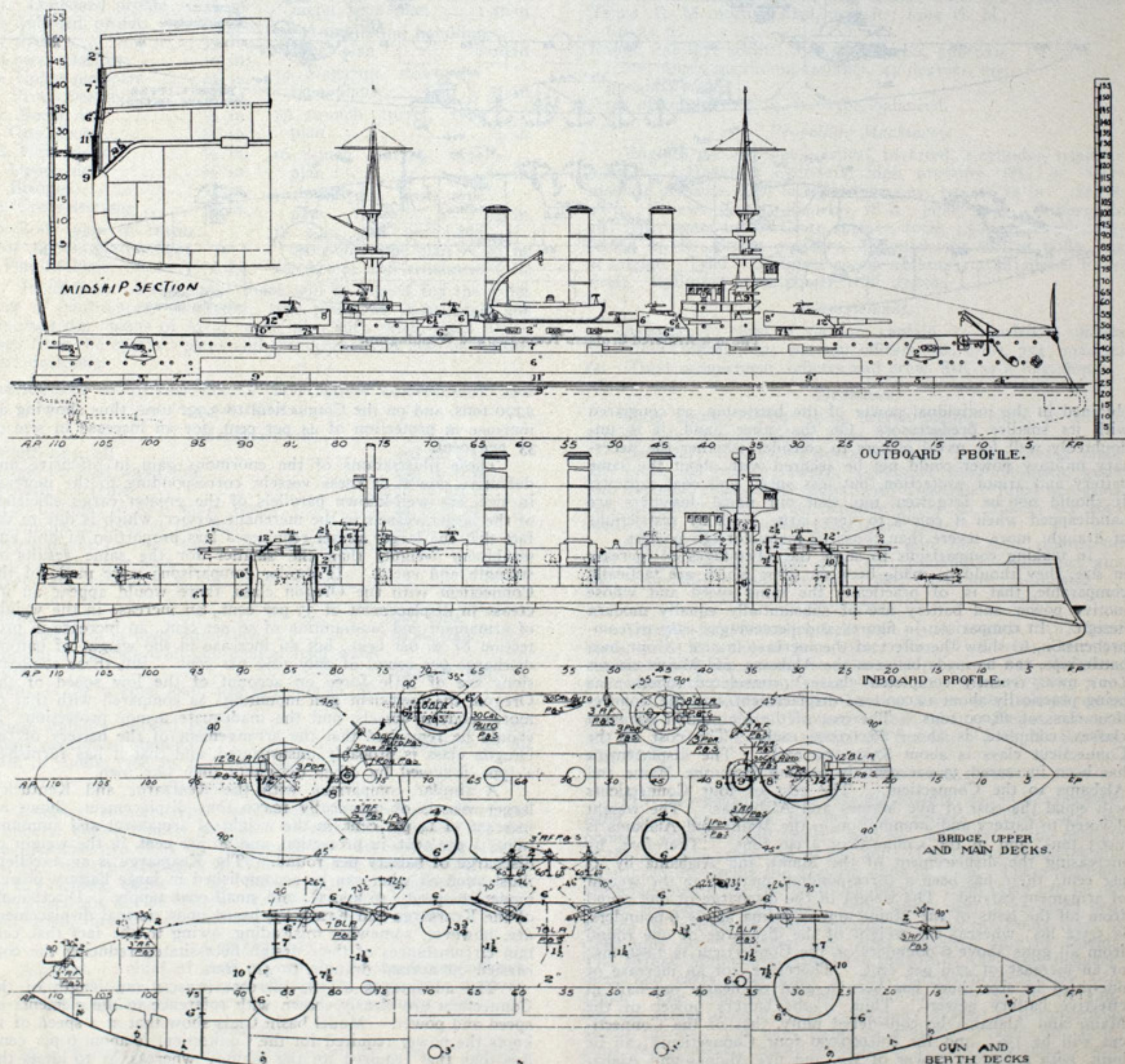
The steel structure is composed wholly of plates and shapes of commercial sizes. All shapes which have heretofore been used for naval vessels only have been discarded, having in view not only cheapening the cost of construction, but obtaining prompt deliveries of steel; the latter being a result never attained in practice when special shapes and small quantities are demanded. The number of structural shapes in the battleships has been reduced to twenty-four, each size of angle bar being counted as a

separate shape. Channel bars are used for beams and bulkhead stiffeners.

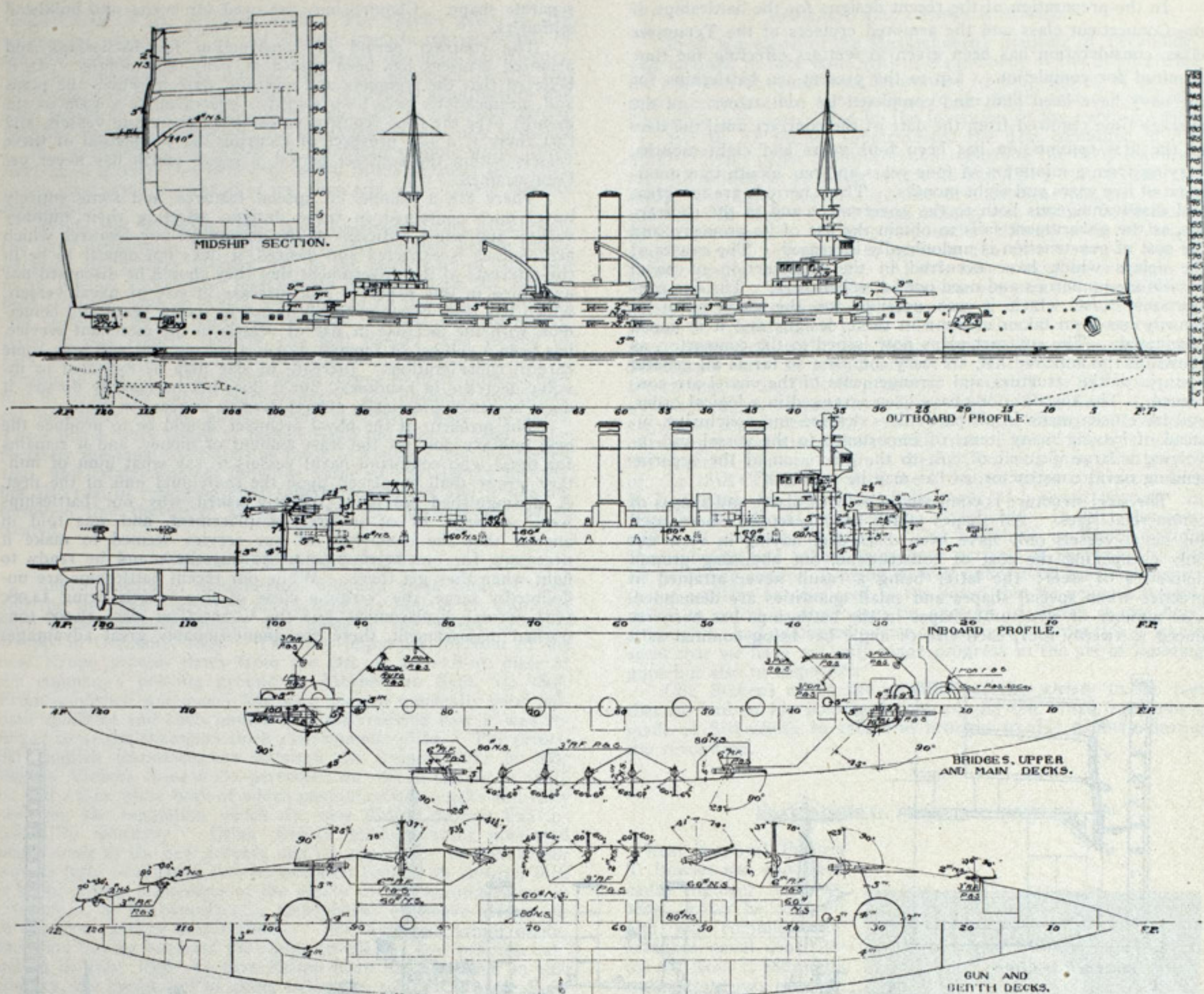
The contract period of construction for battleships and armored cruisers has been placed at forty-two months. It is believed that the complete and accurate state in which the plans and specifications have been issued is equivalent to a gain of six months over the time required to complete preceding vessels, and that there is a fair prospect of securing the completion of these vessels within the contract period, a result which has never yet been attained.

There are a number of special features, and some entirely novel ones contained in these designs affecting their military value; and while criticism of the society on any features which are obvious is expected and desired, it does not appear to be in the interests of the government that they should be discussed nor explained in this paper. The increase in size of naval vessels, which has been common to all navies in recent years and coincident with the increase in size of vessels in the merchant service, has been a subject of remark, and is a matter that will bear some careful consideration. Increase in size may be expected to involve decrease in handiness, but it does not necessarily do so; it does, however, practically always involve increase in cost.

The problem of the naval architect should be to produce the best military unit for the least amount of money, and it remains for those who command naval vessels to say what limit of military power shall be placed upon the individual unit of the fleet. A distinguished foreigner recently asked why our battleships were so large, or of so great displacement, and was told in answer that the conditions of our service seemed to make it necessary for our battleships to go anywhere and be ready to fight when they get there. While our recent battleships are undoubtedly large, the Virginia class of five vessels being 14,980 tons normal displacement, and the Connecticut class 16,000 tons normal displacement, there are unquestionably great advantages



The new Battleships Connecticut and Louisiana.



The new Armored Cruisers Tennessee and Washington.

obtained in the individual power of the battleship, as compared with its smaller predecessors. On the other hand, it is undoubtedly well for naval officers to consider whether the necessary military power could not be secured with about the same battery and armor protection, but less speed and coal capacity. It should not be forgotten, too, that our naval designers are handicapped when it comes to very large ships by restrictions of draught more severe than those of many foreign powers.

In making comparisons to show the advantages of increase in size, they should be made between ships which are tactically comparable, that is, of practically the same speed and whose motive power and battery are of substantially equally modern design. In comparison in figures and percentages easy of comprehension, to show the effect of the increase in size of our own battleships, can be made between the Alabama and Maine classes (our most recently completed classes) considered together as being practically about 12,000 tons displacement, and the Connecticut class of 16,000 tons. The cost of the Maine and Alabama classes, complete, is about \$6,000,000 each. The cost of the Connecticut class is about \$7,500,000 each. The displacement has been increased 33 per cent. in passing from the Maine and Alabama to the Connecticut. The cost of four Connecticuts will equal the cost of five Maines and Alabamas. The weight devoted to battery and ammunition in the Maine and Alabama is 1,003 tons, and in the Connecticut 1,340 tons. Therefore, by increasing the displacement of the Maine and Alabama by 33 per cent., there has been a corresponding increase in the weight of armament carried. The weight of the discharge of one round from all the guns of the Maine and Alabama above 6-pounders, is 5,312 lbs., whereas the weight of the discharge of one round from all guns above 6-pounders on the Connecticut is 7,856 lbs., or an increase of 47.9 per cent. Therefore, for an increase of one-third in size there has been a gain of nearly one-half in effective battery power. Thus, if the battery power of the Maine and Alabama be considered unity, that of the Connecticut will be $1\frac{1}{2}$; and for \$30,000,000 four Connecticuts can be built, with a battery power of six, and five Maines and Alabamas, with a battery power of five. In the case of the Maine and Alabama the weight devoted to armor protection amounted to

2,770 tons, and on the Connecticut to 3,992 tons, thus showing an increase in protection of 44 per cent. for an increase in size of 33 per cent.

These illustrations of the enormous gain in offensive and defensive power of these vessels, corresponding to the increase in size, are well-known parallels of the greater cargo efficiency of the larger vessels in the merchant service, which is due to the fact that the larger vessel requires a less proportion of hull and machinery weights than the smaller for the same results in strength and speed. If similar comparisons were made of the Connecticut with the Oregon class, there would appear an increase in displacement of 55 per cent., an increase in the weight of armament and ammunition of 56 per cent., an increase in protection of 36 per cent., but an increase in the weight of battery discharge per round of only $10\frac{1}{2}$ per cent. But these comparisons are of little force on account of the low speed of the Oregon, the inefficient gun mountings as compared with that of more modern vessels, and the inadequate armor protection. It should be remarked that the arrangement of the battery of the Oregon class is probably unsurpassed, and that it has furnished a type followed by other designers than our own.

A similar comparison with the Kearsarge and Kentucky, larger vessels of practically 12,000 tons displacement, shows an increase of 14 per cent. in the weight of armament and ammunition, 34 per cent. in protection, and 20 per cent. in the weight of discharge of battery per round. The Kearsarge is an excellent illustration of what can be accomplished in large battery power, moderate speed (16 knots), and small coal supply. Discussions of the Kearsarge and Kentucky, based upon normal displacement are, however, somewhat misleading, owing to the fact that certain circumstances of their design necessitated reducing the coal carried on normal draught to 410 tons.

The advantages of the increase in size and length of the Connecticut are clearly shown with reference to the elements of speed and power. Model basin trials show that at a speed of 18 knots the power required for the Connecticut is about 6 per cent. less than that required for the Maine; whereas, at 19 knots the power required for the Connecticut is nearly 50 per cent. less than that for the Maine.

The normal displacement of the Tennessee class is 14,500 tons an increase of 6 per cent. over that of the Pennsylvania class of six vessels now building of 13,680 tons. Certain features of the new designs have permitted this increase to be almost wholly devoted to armament and armor, thereby producing, at slight additional cost, very much greater military power. The addition to the weight of guns and ammunition carried amounts to 29.7 per cent. over that on the Pennsylvania class, and produces an increase in the weight of one discharge of the battery, amounting to 47.4 per cent. The increase in the weight of protection carried amounts to 30 per cent. of that on the Pennsylvania class, and is devoted to an increase in the armor on the turrets and the redoubts of the 10-in. guns, which replace the 8-in. guns in the forward and after turrets on the Pennsylvania class, and to an increased area of side armor, affording ample protection to the magazines and the supply of ammunition to all guns, and also to a complete subdivision of the main battery by armor bulkheads.

The estimated speed of the Tennessee class is 22 knots, the same as the design speed of the nine cruisers now building of the Pennsylvania and St. Louis classes, and will be affected without an increase in machinery weights. These vessels will be exceeded about a knot in speed by a few foreign armored cruisers, but if their designs had been made upon the prime requisite of speed superior to all vessels of this category, it would have been necessary to sacrifice the battery and protection now assigned which enables them to present a heavy preponderance of battle power over any armored cruisers yet designed elsewhere, and also enables them to deal on occasion with a large proportion of existing battleships. The following are a list of the contract plans:

	Scale.		Scale.
1. Sheer draught	1/4 in.	11. Compartment plan	1-16 in.
2. Midship section	1/2 in.	12. Coal arrangement, type plan	1-16 in.
3. Outboard profile	1/8 in.	13. Ammunition handling, type plan	1-16 in.
4. Inboard profile	1/8 in.	14. Magazine stowage, type plans	1/4 in.
5. Hold	1/8 in.	15. 12-inch turret, type plan	1/2 in.
6. Lower platform	1/8 in.	16. 8-inch turret, type plan	1/2 in.
7. Upper platform	1/8 in.	17. 7-in. gun port, type plan	3/4 in.
8. Protective deck	1/8 in.	18. 3-in. gun port and sponsons, type plan	3/4 in.
9. Berth deck	1/8 in.	19. Armor and armament	1/8 in.
10. Main deck	1/8 in.		
11. Upper deck	1/8 in.		
12. Bridges	1/8 in.		
13. Cross sections	1/8 in.		
14. Bodv plan of traces of decks, plate edges, longitudinals, etc	1/4 in.		

In addition to the above there will be issued for the guidance of contractors, ventilation, type plans, of 1/8-in. scale and drainage type plans of 1/4-in. scale, also such other plans developed from the contract plans and specifications as may be considered desirable.

PARTICULARS OF UNITED STATES BATTLESHIPS CONNECTICUT AND LOUISIANA.

Measurements.

Length over all	456 ft. 4 in.
Length on load water line	450 ft. 0 in.
Breadth, extreme	76 ft. 10 in.
Mean draught to load water line	24 ft. 6 in.
Maximum draught at full load	26 ft. 9 in.
Displacement to load water line, 16,000 tons; full load, 17,770 tons.	
Freeboard, minimum at full load forward, 18 ft. 3 in.; aft, 17 ft. 9 in.	
Normal coal	900 tons.
Tons per inch at load water line	63.16 tons.
Moment to change trim one inch at load water line	1,544 ft. tons.
Trans. G. M. normal load, 4.42 ft.; long G. M., 521.22 ft.	
Range stability normal load	68 degrees 18 in.
Angle maximum stability	39 degrees 21 in.
Area of rudder, 288 sq. ft.; type, balanced.	

Propelling Machinery.

Engines, No. 2; type, vertical triple-expansion. Diameter cylinders, high pressure, 32 1/2 in.; intermediate pressure, 53 in.; low pressure, two of 61 in. Stroke, 48 in. Screws, No. 2. Boilers, No. 12; type, Babcock & Wilcox. Grate surface, total, 1,100 sq. ft.; heating, 46,750 sq. ft. Steam pressure, designed, 250 lbs. at engines, 265 lbs. at boilers. Trial.—Designed speed, 18 knots; trial speed, forced draft, indicated horse power, 16,500.

Complement.

Admiral, 1; chief of staff, 1; captain, 1; wardroom officers, 19; junior officers, 10; warrant officers, 10; crew, 701; marines, 60. Total complement, officers, 42; crew, 701; marines, 60.

Ordnance.

Main Battery.—Four 12-in. breech-loading rifles, 40 caliber; eight 8-in. breech-loading rifles, 40 caliber; twelve 7-in. rapid-fire, 45 caliber.

Secondary Battery.—Twenty 3-in. rapid-fire, 50 caliber; twelve 3-pounders, S. A.; six 1-pounders, automatic; two 1-pounders, S. A.; two gatling, .30 caliber; six automatic Colts, .30 caliber; two 3-in. field guns; torpedo tubes, none.

Ammunition.—12-in. rounds per gun, 60; 8-in. rounds per gun, 100; 7-in. rounds per gun, 100; 3-in. rounds per gun, 300; 3-pounder rounds per gun, 600; 1-pounder rounds per gun, 960; .30 caliber automatic.

Protection.

Armor.—(a) Water-line belt, top, 11 in.; bottom, 9 in., decreasing to 9 in., 7 in., 5 in., 4 in. (b) Upper casemate 7 in.; lower casemate, 6 in. (c) Upper athwartship, 7 in.; lower athwartship, 6 in. (d) Barbettes, 12 in., 10 in. and 7 1/2 in.; 8 in., 6 in. and 4 in.; sponson, 2 in. (e) Turrets, 12 in.—12 in. and 8 in.; 8 in.—6 1/2 in. and 6 in.; diagonal, none. (f) Conning tower, 9 in.; signal tower, 6 in. (g) Tube, 6 in. Protective deck, 1/2 in. Slopes, forward, 2 1/2 in.; midship, 2 1/2 in.; aft, 2 1/2 in.; flat, 1 in.

PARTICULARS OF UNITED STATES ARMORED CRUISERS TENNESSEE AND WASHINGTON.

Measurements.

Length over all	504 ft. 6 in.
Length on load water line	502 ft. 0 in.
Breadth, extreme	72 ft. 10 1/2 in.
Mean draught to load water line	25 ft. 0 in.
Maximum draught at full load	27 ft. 0 in.
Displacement to load water line, 14,500 tons; full load, 15,950 tons.	
Freeboard, maximum at full load forward, 21 ft. 3 in.; aft, 18 ft. 6 in.	
Normal coal	900 tons.
Tons per inch at load water line	59.70 tons.
Moment to change trim one inch at load water line	1,483 ft. tons.
Trans. G. M. normal load, 3.30 ft.; long G. M., 616.25 ft.	
Range stability, normal load, 72 degrees, approximate; angle maximum stability, 41 degrees, approximate.	
Area of rudder, 263 sq. ft.; type, balanced.	

Propelling Machinery.

Engines, No. 2; type, vertical, inverted, 4-cylinder, triple-expansion. Diameter cylinders, high pressure 38 1/2 in. intermediate pressure, 63 1/2 in.; low pressure, two of 74 in. Stroke, 48 in.; Screws, No. 2; diameter, 18 ft.; pitch, 22 ft. Boilers, No. 16; type, water-tube. Grate surface, total, 1,590 sq. ft.; heating, 68,000 sq. ft. Steam pressure, designed, 265 lbs. at boiler, 250 at engine. Trial.—Designed speed, 22 knots; trial speed, forced draft. Indicated horse power, trial, 23,000.

Complement.

Admiral, 1; chief of staff, 1; captain, 1; wardroom officers, 19; junior officers, 12; warrant officers, 10; crew, 754; marines, 60. Total complement, officers and crew, 858, as a flag-ship.

Ordnance.

Main Battery.—Four 10-in. breech-loading rifles, 40 caliber; sixteen 6-in. breech-loading rifles, 50 caliber.

Secondary Battery.—Twenty-two 3-in. (14-pounders) rapid-fire guns, .50 caliber; twelve 3-pounder semi-automatic guns; two 1-pounder automatic guns; two 1-pounder rapid-fire guns; two 3-in. field pieces; two machine guns, .30 caliber; six automatic guns, .30 caliber; torpedo tubes, none.

Ammunition.—10-in. rounds per gun, 60; 6-in. rounds per gun, 200; 3-in. rounds per gun, 300; 3-pounder rounds per gun, 500; 1-pounder rounds per gun, 1,380; .30-caliber, automatic.

Protection.

Armor.—(a) Waterline belt, 5 in.; 3 in. at ends. (b) Casemate, 5 in. in wake of 3-in. guns; 2 in. N. S. (c) Casemate athwartship, 5 in.; casemate athwartship, 5 in. (d) Barbettes, 7 in. and 4 in.; sponsons, 2 in. N. S. (e) Turrets, 9 in., 7 in., and 5 in.; diagonal, 5 in. (f) Conning tower, 9 in.; signal tower, 5 in. (g) Tube, 5 in. Protective deck, 1/2 in. Slopes, forward, 2 1/2 in. N. S.; midships, 3 1/2 in. N. S.; aft, 2 1/2 in. N. S.; flat, 1 in. N. S.

DISCUSSION ON ADMIRAL BOWLES' PAPER.

Prof. Hovgaard thought that the country was to be congratulated upon the design for the new cruisers. "There are two points I wish to speak about," said he, "and that is the position of the gun and protection of the gun. The best positions should be utilized by placing the heaviest guns in them. These positions are undoubtedly the end positions, because from them can be obtained the best field of view. Guns ought also to be given protection in relation to their importance. The St. Louis class of 9,880 tons carry fourteen 6-in. guns protected only by shields. The British Monmouth class have practically the same displacement and carry their guns in twin turrets protected by 5-in. armor. The Pennsylvania has two 8-in. guns at end of ship, but the armor does not offer immunity against a derangement of the turrets. The new design of cruisers provides for 10-in. guns well protected and all objection is avoided. Compared with the British Drake class of practically the same displacement they show an enormous increase in power in favor of the American

vessels. The new armored cruisers may really be called cruiser-destroyers."

Mr. W. L. Dobson could not see wherein the new designs could be improved and especially commended the arrangement of splinter bulkheads, whereby each gun is practically in an isolated casement.

Admiral Bowles in reading his paper had made an observation aside to the effect that it was impossible to compare costs with foreign battleships owing to the fact that armor entered so largely into the cost of the vessel complete, and that the price of armor seemed to bear no relation whatever to the state of the market. This remark caused Mr. G. C. Hemming to relate a little experience of his own. He was in need of material to complete an undertaking on his own account and submitted his specifications to the steel makers, who agreed to furnish the material at the rate of \$23,500 per ton. Obviously as this was a prohibitive price he appealed to Krupp who furnished the material for \$6,680 per ton, though of course, considerably less than a ton was involved in the order.

MR. GEORGE W. DICKIE.

Mr. George W. Dickie was born July 17, 1844, at Arbroath, Scotland. He comes of a family of ship builders who had for several generations pursued the art. While still a child Mr. Dickie moved with his parents from Arbroath to Tayport, Fife, Scotland. At the age of seventeen he was apprenticed to the engineering trade on the North British railway. At the end of his five years' term of apprenticeship Mr. Dickie joined his father and brothers as a member of the firm of William Dickie & Sons, ship builders and engineers, at Tayport. In 1869 he went to California, settling at San Francisco, and was engaged from



Mr. George W. Dickie.

1870 to 1883 as engineer at the Risdon Iron Works. In 1883 he joined the Union Iron Works, becoming manager and also a director of the company. This position he has held ever since. Mr. Dickie has had general supervision over the construction of all the war vessels that have been built by the Union Iron Works and many of his ideas have been incorporated by the navy department of the United States in the construction of war vessels. Mr. Dickie is a member of the council of the Society of Naval Architects and Marine Engineers; he is a past member of the council of the American Society of Mechanical Engineers, is a life member and past president of the Technical Society of the Pacific coast and is a member of the board of trustees of the California Academy of Sciences. Mr. Dickie has five sons and a daughter. All the sons are virtually engaged in ship building.

WHY IT TAKES SO LONG TO BUILD A NAVAL VESSEL.

Mr. F. B. King read Mr. George W. Dickie's paper upon the subject, "Why it Takes So Long to Build and Equip a Naval Vessel for the United States." Mr. Dickie, who is the manager of the Union Iron Works, San Francisco, prepared the paper for the purpose of starting discussion and in this he most admirably succeeded. Mr. King read the paper with emphasis on the humorous parts of it and it was evident before the reading was half over with that some spirited replies were in waiting. There was an abundance of defense from the standpoint of the naval constructor, and if the paper had come from any other source the result would probably have been some ill feeling. A few of the members took the paper very seriously, but Secretary Capp of the society, who had been superintending constructor at San Francisco, and was therefore speaking from the view of a naval officer as well as a close acquaintance of Mr. Dickie, rounded out the discussion in a happy way. "As you may know," he said, "Mr. Dickie is one of the most charming of men and a profound humorist. We all know that relations between naval constructors and the contractors should be harmonious. Their troubles are by no means as serious as they would appear from this paper. If they were the records of ships built by the Union Iron Works would not have been known to the world." Mr. Dickie's paper follows:

It is not the desire of the writer of this paper to find fault with the present system of producing naval vessels for our government by contract, or to bring about a discussion that might hinder, rather than help, the efforts of those responsible for the ship designs prepared at our navy department, but rather to point out what in his opinion are the chief causes of delay in building these vessels, and thereby bring about such a discussion on the

methods of design and construction now practiced as will help to open the way for better methods, and give the technical advisors to the navy department the benefit of an unofficial discussion of this very important subject amongst those who usually have to handle such matters under official restraint. While it might be considered as taking somewhat of a risk to let such a cranky subject loose amongst the members of this society, yet we will endeavor to give it sufficient metacentric height to keep the right side of it up, and if it be handled with great care, the building of naval vessels, even in the navy yard, will suffer no more damage from the discussion of this subject than they are likely to suffer afterwards from the building of submarine torpedo boats.

THE SUPERINTENDING NAVAL CONSTRUCTOR.

In dealing with this subject the author naturally looks at it through the eyes of a contractor, which to the general public means dishonest eyes. We sometimes think that the navy department leans toward the public's estimate of a contractor; else why so many provisions in specifications and contracts to protect the second party, who is the stronger, against the first party, who has only his own consciousness of honesty, and his honor as a ship builder, to protect him? In considering certain causes of delay in building naval vessels, the relationship of the superintending naval constructor, or the senior inspector of machinery, to the contractor, may, of necessity, require to be discussed, and in this connection the author desires to state that in his opinion, based on a somewhat extended actual experience, no other government can boast of a finer staff of competent naval constructors and marine engineers, in charge of new work under construction for its navy, than that of the United States navy department. In fact, the ability of the superintending naval constructor, or senior inspector of machinery, is often quite embarrassing to the simple ship builder. We have often been astonished at the almost supernatural ability of the young naval constructor to acquire knowledge on subjects outside of his own profession. Let the bureau of construction and repair, for instance, assume responsibility in regard to certain electrical installations on naval vessels, and in three months thereafter the naval constructors at the various yards will be farther advanced in the application of electrical science to the matter in hand than the contractors' expert, who has given his whole attention for years to this special work. We do not refer to this fact, astonishing as it is, in order to raise any doubts as to its reality, as it must have been observed by others having the same relationship to the young naval constructor as the writer. We have admired this remarkable faculty, because it is so rare outside of those whose talents are exclusively controlled by the navy department. We may have occasion in the course of this paper to appear as intimating that the great ability of the naval constructor often acts as a cause of delay in the building of the ship, and some statements may appear to have a personal tone. It will therefore be understood that no one is meant when anyone is referred to in connection with any part of this subject.

One of the most important causes of delay in the construction of naval vessels is the habit which has hitherto prevailed of designing such vessels while they are under construction. We do not think that it will ever be possible to so design such ships that no change will appear desirable while they are building. It is not necessary that every detail plan should be complete before the structural work begins, but the designs should be complete in every particular, and the specifications should state distinctly how the actual details are to be carried out. One of the most recent specifications issued by the navy department requires that 253 of the most important items in construction should be built as directed, which means that at the time the specifications were written no one connected with the design for the vessel could write down distinctly just how that design was to be carried out. The ship builder would like to carry out the work just as he thought it should be carried out when he made his estimate of cost, but between him and that honest purpose of his there stands the superintending constructor and his numerous assistants, and after them, the bureau they represent. Plans are made, only to be returned over and over again as unsatisfactory, and what seemed plain enough to the simple-hearted ship builder when making his estimates, becomes now so complicated that the first year's time of the contract is lost in finding a way to carry out the contract.

DESIGN SHOULD BE COMPLETED BEFOREHAND.

Before the contract is executed the design should be so complete that all structural materials required could be ordered at once, without having to submit new plans for approval. The latest plans from the bureau of construction come nearer meeting this requirement than any we have had hitherto. The location and dimensions of every compartment in the vessel should be determined, and should not be subject to change. The dimensions of every armor plate should be shown, and it should be ascertained beforehand that such dimensions are within the manufacturing capacity of the armor makers. The armament should be all finally settled as to amount and location, and the type of all gun ports not only indicated, but practically worked out. The magazines should be worked out in sufficient detail to demonstrate that they will properly stow the amount of ammunition they are specified to carry. All means of handling ammunition should appear on the original design, and in capacity should correspond with the specifications. The arrangement of all machinery should be shown, with all piping and platforms, with a practical

plan of getting into and out of machinery compartments. And in all such plans of machinery and boiler compartments, the bulkheads should be shown their actual thickness of 12 inches, with deck beams and coamings that reduce the available space so much. This would save much time later on in rearranging machinery that must go into a space that has been reduced by the framing of its walls. Drainage and ventilation should also be fully worked out, as part of the original design. We understand that in future additions to the navy of the United States something of this kind will be attempted at the navy department. If this should be successfully carried out, and there is no reason why it should not be, these vessels will be several months farther advanced at the date of the contract for their construction than has usually been the case, and many changes that have hitherto been necessary, to meet the requirements of the design, will be obviated.

A curious notion has crept into the public mind that the builders of naval vessels are very much in favor of original plans and specifications that involve them in numerous and extensive changes, and it is often claimed that the principal skill possessed by the builder of naval vessels is that of showing changes to be necessary. It is hardly necessary, before so many of these builders, to make any statement in contradiction of this fallacy, but we find that this idea prevails even among ship builders who have not had experience with the navy Department. Changes are seldom proposed now by the builders, unless the work cannot be carried out without them. Nearly all changes are proposed either by the superintending constructor or the bureau of construction. These changes not only lose time for the builder, but in nearly every case money also. The board on changes, in fixing the actual cost of any change made, is not allowed to include any margin in its estimate against loss, nor the consequent loss that results from stopping work in one direction and beginning it in another direction, after perhaps several weeks' or months' discussion over the proposed change. And when the board has fixed the actual cost, the builder must accept the amount whether he likes it or not; but if the department does not like it, the board must reconsider its estimates until the department is satisfied.

COMPLETE PLANS WOULD OBTAIN MANY CHANGES.

Complete plans as part of the contract, that would obviate all necessity for changes, would not only save much time in construction, but would save much money for the builder as well. The engineering department has fewer changes, and seldom any extra cost over the contract price. This is the result of having fewer representatives at the ship yards, and those have their duties limited to inspection, and not to design; a wise arrangement, both for the navy department and for the ship builder. Much time would also be saved in the preparation of working details for the shops and yard, if the specifications were carefully prepared from a complete design. In the hull department at present every shop or ship yard detail must be revised by the superintending constructor, not to see if it meets the requirements of the specifications, or carries out in detail the design adopted, but as to whether, in his opinion, it is the kind of design that should be used; and it often goes through half a dozen or so of his subordinates, who each has his own opinion to express in regard to it. These men in many cases have come from the shops or the draughting rooms of the establishment whose work they now have an opportunity to criticise, and in some cases would not likely have been trusted to get out the designs they now have a chance to give their opinions upon.

In general, this system involves the builder in the making of many working plans many times over, before the superintending constructor is satisfied with them. Then they may go to the bureau for final approval; but it does not follow that because these plans have been made and re-made over and over again, until the superintending constructor thinks they are right, the bureau will approve them, and the work go on. For at the bureau they are subjected to another process of examinations and comparisons with work from other shipyards where similar ships are in course of construction, with a good chance of being sent back for revision, with perhaps copies of plans for similar work that had been approved for a sister ship building elsewhere, and this often sends the poor shipbuilder back to the first plan he submitted to the constructor. Where plans have to be submitted to the bureau for approval, and all plans involving any design have to be so submitted, we see no advantage in such plans being labored on sometimes for months by the superintending constructor and his staff of draughtsmen, and by them returned over and over again to the builder, for changes and corrections, then finally sent to the bureau for a similar process, there ending often in disapproval.

Why should not the builder prepare his plans as he thinks will best carry out the requirements of the specifications and the adopted general designs, submit these plans to the bureau through the superintending constructor, who would give the bureau his opinion and recommendation in regard to them? These plans would reach the bureau without being so marred by changes and erasures, and we are satisfied would be as often approved by the bureau as they are now, saving much time and expense, both to the builder and to the navy department; for a large part of the draughting force maintained by the bureau of construction and repair at the shipyards are employed on this kind of work, that is worse than useless.

The detail plans for work under the bureau of steam engineering number about half as many as those for work under construction and repair. Yet that bureau has no draughtsmen at the shipyards. Every detail goes to the bureau through the senior inspector of machinery, who gives his opinion in regard to the work shown on the plans submitted. The examination is made by the experts at the bureau. These plans are returned approved or modified, as the bureau considers necessary, then the work goes on. Work is never delayed on account of inability to get approved plans for work under bureau of steam engineering. The reason for this is that the senior inspector does not make any effort to design the machinery details, but simply forwards these details as made by the ship builder, with his opinion in regard to them, to his bureau, and no time is wasted in trying to get to a place, the location of which is unknown.

If the designing work attempted by the superintending constructor and his draughtsmen were abandoned, and all plans as prepared by the shipbuilder submitted to the bureau with the constructor's opinion in regard to them, one-half of the time consumed in getting out plans would be saved, and many months less time would be required to complete the ship. Besides, the superintending constructor would be able to devote his time to superintending construction, which would appear to be his duty if his title is correct.

SHOULD BE ONLY ONE NAVAL ARCHITECT.

There should only be one naval architect responsible for the design of the vessel outside of her propelling machinery. Now we have three parties trying to do the work. The bureau of construction and repair, the superintending constructor, and the shipbuilder, and much time is lost in trying to harmonize the ideas of these three parties to the design. As the bureau of construction must finally decide, the time expended by the other two parties is in many cases simply time wasted, and retards construction work on the vessel.

Another cause of delay which especially affects those ship yards situated on the Pacific coast, and far removed from the main sources of material supply, is the rigid requirements of the specifications in regard to the testing and acceptance of materials to be used in construction. It is impossible to order and have on hand every class of material that may be required, and it is quite immaterial in regard to a great deal of the material whether it really meets all of the requirements of the specifications or not. Why should steel material that is under no stress, and cannot possibly be brought under any, be tested just as carefully and rigidly as material that of necessity is always under severe strains? We have seen chocks and distance pieces, for which cast-iron would be just as good as any other material, rejected, and the work delayed, until other material was obtained that would meet say a high tensile test, when its function in the structure was simply to stand a little compression. We feel sure that in regard to such questions the constructor at a navy yard, where a warship is being built, will be obliged to use a good deal more common sense than he thought necessary to fulfill his duties at a private yard. It is true that the bureaus have always been willing to consider special conditions in regard to the requirements of the material specifications, but such consideration has always meant delay.

We find it very difficult, in a paper to be read before this society, to state all the vexatious delays that occur on account of unimportant materials being required to meet a specification that should not apply to them. We are often told that the very best material that can be produced is none too good for government work, which is very true, if rightly applied. But for ordinary purposes ordinary material should be used, and high class material reserved for its proper place in the structure. And we feel sure that if we were called upon to take the place at a navy yard building new war vessels, and perform the duties there of the superintending constructor at the private yards, we would not stop the work until some piece of material for an unimportant part of the structure was especially made at the steel works to meet the requirements of a specification, if there was ordinary material perfectly suitable for the work in stock at the yard.

IT IS THE LITTLE DELAYS THAT COUNT.

While it might be claimed, and is often claimed, that to relax the requirements of the specifications where it serves no good purpose to enforce them, opens up the way to their being evaded where it is of the utmost importance that they be faithfully carried out, such an argument against a proper exercise of judgment in meeting the requirements of a specification would lead us to infer that either the naval constructor was incompetent, or the builder dishonest, and neither inference would be correct. A specification must of necessity leave much to the judgment of the party who is to interpret it, and the manner in which the judgment is applied, will either help the progress of the work or retard it. The little delays that occur every day from this cause, when summed up, will account for months of delay in a three years' contract.

Methods of doing work in the ship yard vary so much in the different yards, that much time is often lost by the superintending constructor trying to make the yard practice where he now is conform with the methods he has seen used in other yards where he has been superintending for his bureau. Interference of this

kind, however much importance it may have in the opinion of the naval constructor, is sure to cause delay and loss to the builder, without any corresponding advantage to the character of the work. Every yard that has accomplished anything has its own methods of reaching a desired result. The naval constructor should simply require that the result be attained, and his education and experience will be advanced, not by trying to direct, but by watching the methods by which the result is attained. Constructors do not always realize how difficult it is to change the methods of doing work, and cannot understand why the ship-builder will not consider the methods that he has studied out for doing the work. He forgets that the ship builder has also studied out the methods of doing this, in conjunction with many years in the actual doing of it, with the kind, character and breed of men he has to do with, and with a far more difficult problem before him than the naval constructor has to face. The naval constructor aims at only one result—that of satisfactory workmanship. The ship builder, if he is to remain such, must not only have as a result satisfactory workmanship, but he must obtain it at a cost not to exceed his original estimate, and if, by interfering with his methods, one of the results only is obtained, the ship may be built and the builder ruined. The best result will always be produced in any yard by the methods that have become the practice at that yard, and it should never be considered as any part of the duty of a naval constructor at a private yard to endeavor to control in any way the methods of doing work that have grown to be the practice at that yard. If the results desired cannot be obtained by the regular practice of doing work at that yard then government contracts for the building of naval vessels should not be placed with such a yard.

STANDARDIZATION OF PARTS WILL HELP THE BUILDER.

We have stated that the naval constructor should not be the naval architect, neither should he be the ship builder, unless in the one case he is to be responsible for the design, and in the other case he is to find the wherewithal to meet the obligations of the pay roll. We have often seen work being prosecuted to reach a certain result in the construction of a naval vessel stopped, because the naval constructor desired to consider the possibility of reaching the same result in another, and perhaps more direct way. There may have been twenty ways by which the same result could have been reached, and work may be stopped for six weeks while the superintending constructor is in search of the shortest way, and yet by the longest of all the twenty ways the work might be done in a week. This is no fancied condition existing only in the mind of the writer; it is the normal condition under which construction work is carried on at a private yard, on naval vessels, and it is one of the most serious causes of delay that the builder has to contend with, and the most difficult one to make claim in regard to, as the intention of the naval constructor is to help and not to hinder the work.

We believe that the effort now being made by the bureau of construction and repair to standardize a large number of the fittings used on naval vessels, will help the builder in regard to time, as these fittings can be made up in quantities and carried in stock ready for use when the structure is ready to receive them. But we must not expect too much from any system of standards. If restricted to what is generally termed fittings, standards will prove a benefit both to the builder and to the navy in general. The danger in regard to standards is the desire to carry them into a class of work that, from its nature, must be making continual progress in order to meet ever changing conditions. The standard can never be the best of anything that is ever growing better. When either a man or the thing he makes is standardized, they are dead. The bureau that first sent out standard fittings for electric work on naval vessels, is the most changeable in its requirements. New standards to take the place of standards in use come so rapidly from this bureau that it is unsafe to have anything on hand, and we are sure that all the naval bureaus are too progressive to be buried under their own standards.

We have endeavored in this paper to point out some of the reasons why it takes so long to produce a naval vessel under the conditions that force the builder to follow a certain course. We have done so in order to provoke discussion on the subject. We have treated it from our own standpoint—that of a ship builder whose works are far from the navy department. All ship builders doing naval work may not be in the same position, although on most of the points raised we think all the ship builders are confronted with the same difficulties.

We will be very sorry indeed if anything in this paper should be considered as a reflection on the naval constructors. We know them so well, and they know us so well, that we have no fear that anything we have said in this paper will be misunderstood. In every struggle the writer has had with the naval constructor, it has been his misfortune to be defeated, not because his case was bad, but simply because the constructor's skill was superior to his own. But if we lost our case, we never lost our friend, in a tussle with the constructor.

VIGOROUS DISCUSSION PROVOKED.

The first person to discuss the paper was Mr. R. L. Newman, who was inclined to support the observations of Mr. Dickie. He said that when he first came to the United States and entered into ship yard work he was surprised at the large corps of constructors at the ship yards for the navy department. Upon inquiring as to the necessity for it he was informed that naval

work was comparatively new work in the United States and that it was deemed essential to have a large corps of instructors. He referred to the fact that when he was assisting in building the warship *Narcissus* in England, the government was represented by a captain, a chief engineer and a superintendent. He believed the navy department of the United States more difficult to get along with than the British admiralty. If the British admiralty disapproved of the contractor's plans it submitted a copy to be followed and that was all there was to it. He thought that if other countries could get along with a central office in London or Paris that it might be found to work satisfactorily in this country also.

Mr. R. C. Monteagle of the Gas Engine & Power Co. and Charles L. Seabury & Co., Consolidated, Morris Heights, N. Y., took a spirited stand in opposition to Mr. Dickie and censured him especially on account of comparisons made between the methods of the engineer corps and the constructors. He said:

"It seems a matter of regret that a member of this society should have made such invidious comparisons between the methods and the men of the two great branches of the navy. These comparisons are none the less invidious that they are coated with sugar. The explanation that 'it will therefore be understood that no one is meant when any one is referred to in connection with any part of this subject' is slightly humorous for Mr. Dickie's desires as expressed at the beginning of the paper lead one to suppose that he will treat the subject in a sympathetic manner, but only disappointment results. Stripped of all verbiage, Mr. Dickie's paper is an attack, and to make his object entirely beyond doubt he compares the methods of the two bureaus. The old proverb that 'comparisons are odious' never was more fitly illustrated. My quota of experience with naval constructors is that they simply require 'the result to be attained' and do not attempt to force their methods on the contractor, supposing their methods to be at variance. Any contractor who yields to an inspector of machinery or construction in the matter of methods of doing work does so by his own choice. He is not obliged to do so by law or custom. In regard to the use of material which has not been tested in places where there is no severe strain, all that is necessary in such a case is to get permission from the inspector to use such material, and I have never yet known an inspector who would refuse to do so in a reasonable case."

Rear Admiral Bowles then got upon his feet. "I presume," said he blithely, "that I am expected to say something. I wish to say that there has been no collusion whatever between me and Mr. Dickie in preparing this paper. I was afraid that I couldn't be quite as funny as Mr. Dickie so I took the precaution to write my remarks. (Here the admiral pulled a page of type-written manuscript from his pocket but posterity will never know what it contained as he neither read it nor referred to it again.) Mr. Dickie has torn away the veil and revealed the secrets of his prison house. I wonder what would happen if I should open the doors of my closets and reveal also what I know about contractors. I believe the suggestion has hitherto been made that construction of war vessels should be superintended by ancient mariners. Does an owner of a steamship have his captain superintend her building? No, he turns that work over to a classification society which does nothing else than register the construction of vessels. Some of the great steamship lines maintain a technical staff of their own to watch over the construction of their fleets. I don't feel the necessity of making any defense whatever. I have already indicated that no doubt the basis of the author's complaint that the contract plans and specifications are incomplete, inaccurate and indecisive, is well founded. Considering that the art of building battleships in the United States was practically begun about twelve years ago it will probably be admitted that it was a wise and good policy not to attempt, when making the general plans and specifications, to work out in great detail what would have naturally required a great deal of time and for which there was no experience for a guide and which must have been designed to meet conditions not molded nor established into practice. It was, therefore, undoubtedly in the interests of the government, as well as of contractors, to leave a large number of matters to be worked out in detail as the problem developed. At the present time the situation is quite different and admits of the treatment which it is receiving at our hands, of making plans and specifications definite and complete. I believe that it is a sufficient reply to Mr. Dickie to say that the firm with which he is connected has built many successful and well known ships, and that one of them steamed around the Horn. His willingness to share a very large proportion of the credit for the construction of these vessels with the superintending naval constructor is, of course, gratifying."

Mr. R. L. Newman arose to make further reference to the methods of Lloyd's and the British admiralty in dealing with contractors. He thought the distinction entirely marked, in that the naval constructor designs while Lloyd's inspectors simply inspect.

"The gentleman may know more about the merchant marine than I do," replied Admiral Bowles. "He may also know more about the British admiralty than I do, but it would be reasonable to presume that I also know something about the British admiralty. I know that the specifications of the British admiralty are far more vague than ours. They leave everything to be settled at some future time. Their warships get far less inspection than ours. What is the result? For habitability and military

effectiveness they bear no comparison with ours. And as for Lloyd's I know that it has been wrangling with ship builders for the past twenty years. The statement made in reference to it by the last speaker is not borne out by the facts."

NAVAL CONSTRUCTOR TAWRESEY'S DEFENCE.

Naval Constructor John G. Tawresey, who is at the Union Iron Works as the representative of the bureau of construction and repair, sent a communication to the meeting in reply to Mr. Dickie's paper. It was read by Naval Constructor Baxter and is, of course, a defense of the present system. It is somewhat more also in that it is an interpretation of the meaning of Mr. Dickie's paper. Mr. Dickie evidently did not intend that his paper should be accepted as fact without discussion. Mr. Tawresey wrote:

"The actual time taken to construct most of our naval vessels has been prolonged by delays in obtaining armor and steel material of certain classes, and in some cases by strikes. Deducting delays of this nature from the actual time the vessels were under construction, we have left what might be called the normal time for construction in the United States. This time is undoubtedly in excess of that required by one or two of the great naval powers, but it is shorter than that required by others. The author of this paper states what he considers the principal causes tending to prolong the normal time for construction. The subject is certainly one of great importance, and if in the paper and discussion the purpose to discover the cause, and to discover better methods, and to help those responsible for the building of our fleet, are even partially realized, a great service will have been rendered to the country and to those engaged in ship building. Ordinarily I would not venture to discuss my official duties before the society, but as the superintending constructor's acts from the bulk of the subject matter of this paper, and as he is cited as the major cause of delay, it is necessary, if the discussion is to be profitable, that an authoritative statement be made by some one familiar with the duties and practices of superintending constructors for the United States navy. In a paragraph referring to material the author speaks of 'vexatious delay.' Were it not that he is a person of such wide experience and such known sound judgment, I would suggest that the vexation has magnified most of the causes of delay stated in his paper. I can not agree that more than one of them is a real and material cause of delay. In my experience I have not known anything to warrant the statements as to the superintending constructor and those employed under him doing design work; neither have I heard of the superintending constructor interfering with the methods of doing work. These statements do not appear to be based on any recent occurrence at the author's own yard, and he must be misinformed as to the work of the draughtsmen under the bureau of construction and repair at the ship yards. I do not know of a single one who is engaged on general design work, and do not know of a superintending constructor who finds any time for such work. No doubt in his long experience the author has met with the instances mentioned, but I beg to point out that such instances are of most infrequent occurrence.

THE CONSTRUCTOR OF ASSISTANCE TO THE BUILDER.

"Turning to the paragraph referring to 'the rigid requirements of the specifications in regard to testing and acceptance of materials,' I wish to ask if by 'the constructor at a navy yard' the author does not mean anyone responsible for a part of the ship? Most instances of tests of material at the building yard, and the particular case referred to in the paper, do not come under the superintending constructor at all. I trust that no one will get the impression that every piece of steel worked into minor parts of the hull structure is specially made and inspected. It is a very common occurrence to accept for minor parts material on hand when an examination or test shows it good enough. If the inspector had, in the last few months, used no more 'common sense' in this matter than is indicated, it is hardly probable that the author could have found opportunity to contribute his paper to this year's proceedings. If the superintending constructor were dispensed with altogether and the ship builder allowed to proceed 'to carry out the work just as he thought it should be carried out when he made his estimate of cost,' and to 'prepare his plans as he thinks will best carry out the requirements of the specifications,' and to use any material that appears to him good enough, the period for construction would no doubt be much shortened and the cost lessened, but that condition would scarcely prevail except in the case of a ship building for the contractor himself. Private owners, as well as the government, will on making the original draft, and revising the specifications for their vessels, and since it has not yet been practicable to develop in the original plans and specifications every detail of the vessel and her fittings, the latest service practice at the date of any contract for a new vessel necessarily forms a considerable portion of the contract and specifications. A superintending constructor with a good knowledge of service conditions and service practice, and in touch with the bureau, should be and is a great assistance to any builder of government ships, whether the fact is appreciated by the head of the company or not. The builders, and especially those on the Pacific coast, would not be in a more favorable position if all plans were forwarded direct to the bureau, for the bureau would be no more inclined than is the superintending contractor to approve for the new ship a duplicate of what was used on the ship completed two years ago, or five years ago, regardless

of progress in the meantime, and of changes in the new specifications, and of the fact that the previous fitting may not be proved entirely satisfactory in service. Plans are not made over several times for the superintending constructor that he may look at them and choose the one he likes best. He is only the mouth-piece of the owners, and it is when their instructions have been disregarded or not fully complied with that the first plan is sent back, usually to have some omission supplied but often to have arrangements that have failed on other ships changed and sometimes to be made over. The continued increase in efficiency of each new ship is not achieved by using an old plan—or an old pattern—without considering the matter anew in the light of the latest information at the time of the new contract.

CONFUSED METHOD OF DOING WORK WITH DETAIL OF DESIGN.

"I cannot but believe that the author has confused methods of doing work with details of design and workmanship; methods of shaping frames with unfair framing; and the method of laying off plates with the condemnation of plates for bad butts or bad inch holes. A builder may prefer to butt work that he is required to weld; he may object to work being stopped until his own office prepares and submits plans, and may prefer to proceed with the work without plans, or with insufficient plans, to determine if the scheme will be effective, or if it conflicts with other necessary parts of the vessel; but he objects still more when work done under such conditions is required to be changed. The superintending constructor does, as far as the management, method and order of doing work is concerned, 'simply require that the result be obtained,' but he does not allow work to proceed with the defective plans or with defective material or fittings in the hope that it will finally come out right. I fully agree with the author as to the desirability of complete plans and specifications, and that changes cause delay. When a ship is delayed from other causes, changes are often necessary in order that she may embody the most modern devices when completed. An examination of several hundred recent changes on a number of vessels to reasonably fulfill the author's suggestion that changes should be made by the bureau rather than by the superintending constructor.

"In the building of merchant vessels the method of procedure and inspection is controlled by the ship builder to a much greater extent than in the case of war vessels and it might be profitable to consider if such contracts are carried out more expeditiously than naval contracts. In the absence of a better basis of comparison, the normal times for construction for large vessels or vessels not too dissimilar in size and built at the same yard, might be expected to be proportional to the expenditure for labor. The machinery is usually completed within the period required to build and equip hull, so that the above comparison appears fair when sufficient workmen are not obtainable, and appears to favor the merchant vessel somewhat—when as many men are worked as the space in and around the vessel will allow. In the single case, an average one, for which I have figures at hand, the speed of construction is greater for the naval vessel. If it would appear on more complete investigation that naval vessels are normally constructed as expeditiously as merchant vessels, then the author's principal cause of delay, the superintending constructor, would be eliminated and we would have to turn to the builder and his methods to find a means for reducing the time consumed.

"The author, in his ripe years of experience, secure in our admiration and in a reputation that will ever be remembered, appears to forget that all are at some time chargeable with youth, the experts and draughtsmen employed by the ship builder as well as the superintending constructor and his subordinates; that the ship builder employs both beginners and experienced men and that all are engaged in interpreting specifications and preparing plans that come to the superintending constructor—very often with little or no previous examination by the builder's naval architects, and that these plans are in their original form, only in slight degree, the product of the judgment and experience of the ship builder. It appears to me that if this paper should pass unchallenged it will produce an impression that the author could not have intended, and that will be very unjust to both the ship builder and the superintending constructor. They do not work in a continual state of discord, but on the contrary, I have frequently been informed that in proportion to the number of decisions involved their work is carried on with less disagreement than in the case of merchant vessels. I take it as most creditable to the ship builder, and incidentally to the superintending constructor as well, that this should be the case."

Adjournment was then taken until afternoon.

VALUABLE PAPERS SUBMITTED.

Mr. Lawrence Y. Spear contributes a most Exhaustive Paper on the History of the Submarine—Elicits much Discussion—The Tactics of the Gun—Interesting Debates.

President Griscom presided at the concluding session of the society on Friday afternoon. Discussion of Mr. Dickie's paper was continued. Lawrence Y. Spear, now with the Holland Submarine Torpedo Boat Co., but formerly a naval constructor, said he felt a special right to discuss the paper. He had occupied the position of the oppressor, as Mr. Dickie puts in his Scotch humor, but is now the victim. He did not take the paper as serious as others might take it. There was justice on both sides of the question. On the score of delay due to plans passing back and forth between the government officials and the contractors, there was the other con-

sideration that the contractors were constantly being assisted in complying with service practices and they had often admitted it to him. There are not enough naval constructors for the work, and the enormous demand for draughtsmen has resulted in poor plans from contractors that might be looked upon as an offset for delays. Mr. Spear also said that those who know Mr. Dickie best know that he delights in promoting discussion.

"When building up the new navy," said Mr. F. L. Du Basque, "the initiative was taken by the constructive corps. The ship yards, after the first contracts were let, were pleased to take advantage of the information which the navy could give them. It should not be forgotten that some of the big yards can trace their early progress to assistance which they received from the young constructors. It is quite surprising, however, that in the matter of standards referred to in this paper the navy has not made more progress. The opportunity for standardization of parts in the navy is great but does not seem to be taken advantage of."

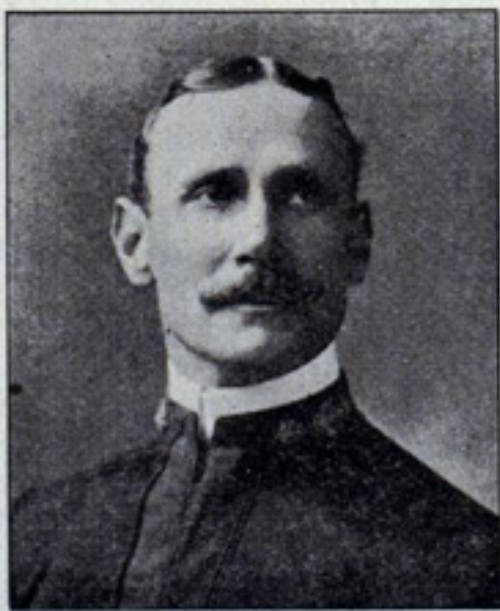
"I sympathize with Mr. Dickie," said Mr. A. G. Rutherford, "but he does not seem to have made a clear case in his paper. Delays are due to two reasons not specially referred to in the paper. We all know of what we are encountering in the matter of delivery of material. It is first necessary to send men to the mills in order to get the stuff, and then what a time we have to get along as the structure progresses! That which is wanted never comes at the right time. There is also the difficulty of getting men suited to the work as it goes along in its different stages. These are, of course, matters of supply and demand, but they are of first importance in considering a subject of this kind."

Robert Curr, who was connected with one of the ship yards of San Francisco up to a short time ago, said that nothing from the east seemed to satisfy the Pacific coast. He gave expression in a very humorous strain to the opinion that the builders of the Pacific had their own methods and were very much inclined to oppose anything that might be suggested from other parts of the country.

Lieut. Com'dr. White spoke of the advantage to young naval officers of the training which they receive when on construction work and the discussion was then concluded by the remarks of Secretary Capps, referred to in a previous paragraph, and in which he directed attention to Mr. Dickie's keen sense of humor and his delight in promoting discussion.

LIEUT. COMD'R. A. B. NIBLACK.

Lieut. Comd'r. A. B. Niblack entered the navy in 1876 from the first district of Indiana (Vincennes) and graduated from the United States naval academy in 1880; has served on the Pacific North Atlantic, South Atlantic, European and Asiatic stations; was employed in surveying and exploring duty in Alaska in 1884-7 and again in 1893 on the boundary survey. He is the author of "The Coast Indians of Alaska and Northern British Columbia." He was inspector of naval militia 1895-6; naval attache at Berlin, Rome and Vienna 1897-8; and on the outbreak of the war with Spain served in the North Cuban blockading squadron, participating



Lieut. Comd'r. A. B. Niblack.

in the capture of Nipe bay in July, 1898. He commanded the torpedo boat Winslow in August, 1898, and was transferred to the Asiatic station in November of the same year to join the United States flagship Olympia. He served two years through the Philippine campaign and five months in the North China expeditionary force in 1900. In December, 1900, he was appointed secretary of the naval commission to locate a site for a naval station in the Philippines and afterwards had charge of the survey of the place chosen at Olonpago, Subic bay, Luzon island. He was appointed inspector of target practice in 1901 and is now on waiting orders for sea. His paper on the "Tactics of the Gun" is the outcome of his experiences as inspector of target practice. At the first meeting of the Society of Naval Architects and Marine Engineers Mr. Niblack read a paper on "Coal Bunkers and Coaling Ship" which has largely influenced the question of bunker arrangements in recent ships. Mr. Niblack's other papers before the society have been "Tactical Considerations in War Ship Designs" in 1895, and "Tactical Considerations Involved in Torpedo Boat Design" in 1899. Mr. Niblack is best known in his profession for his interest in signaling and tactics. He was promoted to lieutenant-commander in June, 1902.

THE TACTICS OF THE GUN.

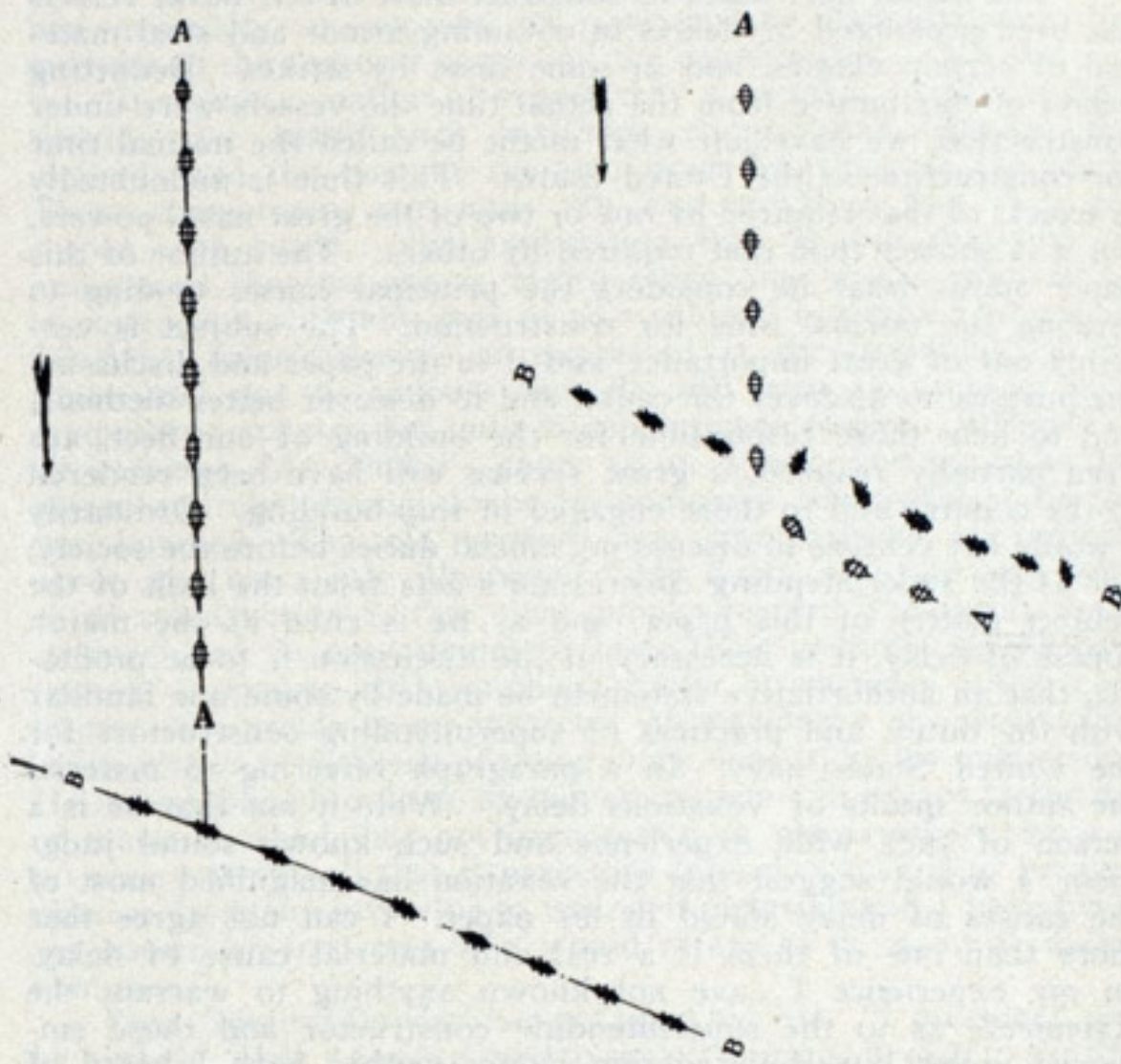
At the close of the discussion of Mr. Dickie's paper Lieut. Com'dr. Albert P. Niblack's paper upon "The Tactics of the Gun" was read by Lieut. Com'dr. W. P. White, in the absence of Mr. Niblack. He gave a most appreciative reading of it. The paper follows:

The battleship is the epitome of sea power. Reduced to its simplest terms it is a floating gun platform. As a unit of offense

it contains, on a given displacement, the maximum of concentrated destructive power, (a) for battle on the high seas for which it is primarily designed, and (b) for coast attack, which is its secondary and seldom used purpose. The difference between the tactical values of battleships and of cruisers, torpedo boats, submarines and rams, are those of degree rather than of kind, for each merely chooses some weapon or some quality of the battleship and sacrifices everything else to it. The special tactics suited to each are dictated by the battleships. Cruisers, torpedo boats and rams must have speed to avoid encountering them unwillingly or to deliver their blow in the shortest time so as to escape as

Fig. 1

Fig. 2.



much gun-fire as possible. Submarines must be invisible. Nothing is here said of monitors, for their function is purely harbor defense, and as gun-platforms in a seaway they are wretched owing to rapid oscillation. On the other hand in the design of the battleship we must secure immunity from the other classes of vessels, but this is done as far as equipment, construction and ordnance are concerned by quick maneuvering qualities, powerful secondary batteries, search lights, nets and other auxiliary appliances, but, primarily, battleships are meant to fight battleships on the high seas, and it is in this view of gun against gun that we shall consider the question of tactics.

It is the function of the ram and of the torpedo to penetrate the underwater body of a ship, and breaking down its watertight subdivisions, or striking it in a vital point such as the magazine or boiler, to destroy it. It is the function of the gun to put out of action the battery and personnel, but as long as a ship retains her motive power, steering gear and her personnel other than that at the battery, the gun is almost powerless to destroy. To be more explicit, it is only by luck or by indirection that a modern battleship can sink another by gun-fire alone. We need not in the future expect to set ships on fire by gun-fire, as at Santiago or Manila, and, indeed, we have a long way to go before we can expect to achieve victories over our next adversary. This is a warning and not a prophecy.

The individual gun is the unit of offense, in one sense, but the combined fire of as many guns as possible directed according to a definite scheme by means of well organized fire control alone means victory. The key to modern fleet actions is concentration of gun-fire. To achieve this we must install our guns properly, and we must of all things train our personnel. Fleet formations should be based on gun-fire, and in battle we should limit tactical movements to those which least disturb it. The object of all tactical maneuvers or movements of a fleet previous to or in a fleet engagement should be:

First, to get and keep the enemy within a close effective range.

Second, to endeavor to get a superior position in order to mask some of his fire, or increase the effect of your own.

Third, to hold an advantage gained or losing it to maneuver for a fresh one.

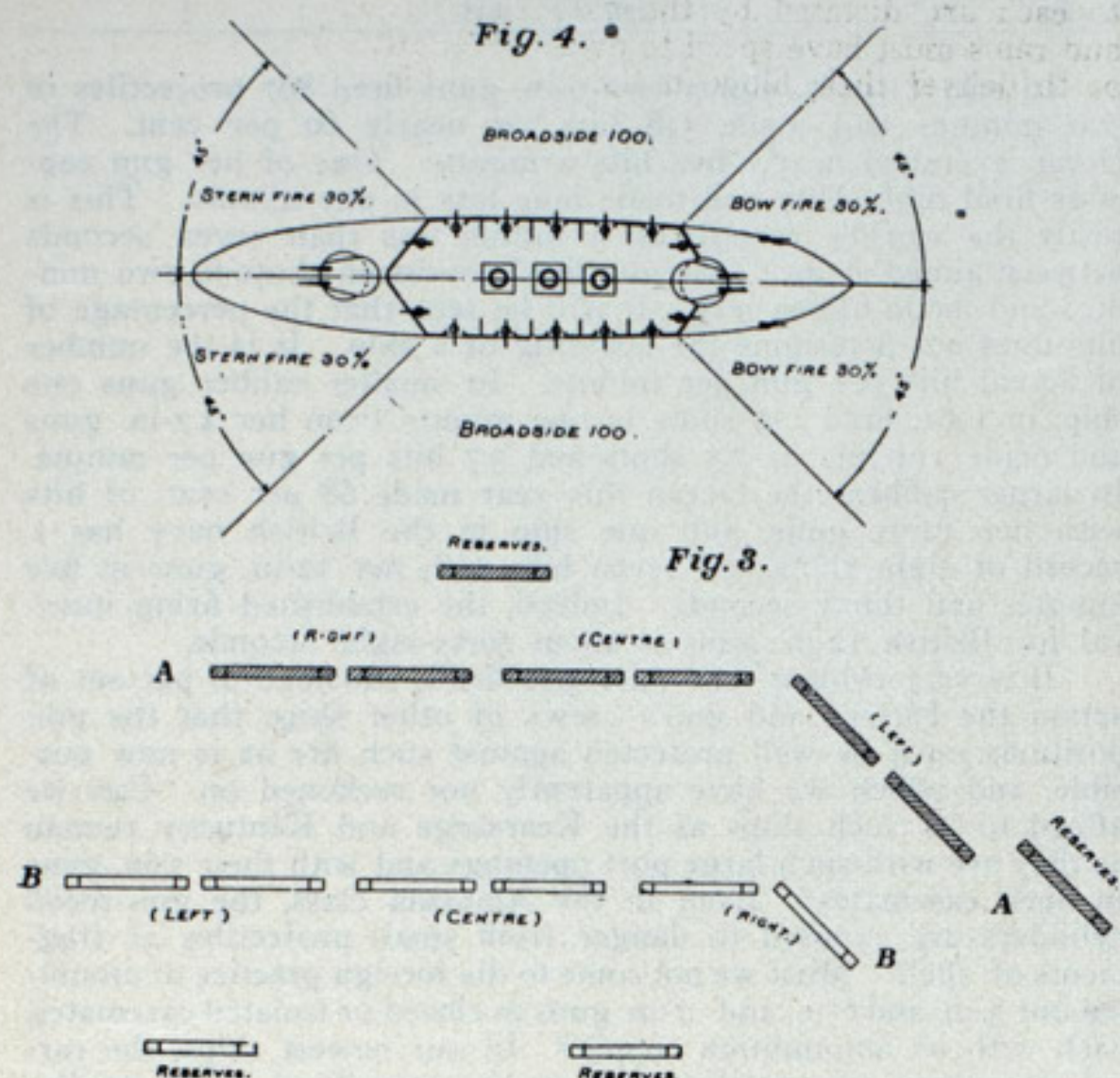
Fourth, to avoid waste of ammunition.

Fifth, to get out of a position of disadvantage or one in which a move of the enemy may threaten to place you.

Sixth, to concentrate gun-fire on certain ships of the enemy in order to reduce the tactical efficiency of all his ships by crippling one or more.

Seventh, but of all things to deliver a rapid crushing fire at the earliest possible moment, thereby injuring at once his initiative and increasing your own offensive power in a geometrical ratio as you destroy his.

Modern steam fleet-tactics differ in many essentials from the tactics of the sailing ship period and from military tactics on shore. In the days of sailing ships practically all guns were necessarily mounted in broadside, and bow and stern fire, for structural reasons, were inconsiderable. The natural formation was column (or "line ahead," as it is called abroad), as this gave the greatest effective fire, viz., broadside. In the approach of such fleets to each other in an engagement very few guns



could be brought to bear, and the preliminary maneuvering was generally to secure the weather-gauge, or windward position, which gave the advantage of forcing the engagement, or withdrawing from it. The supreme tactical advantage was gained by "breaking the enemy's line" (column of vessels), throwing his formation into confusion, raking his nearest ships in passing through, and escaping most of his broadsides while delivering your own successively and in its most effective form. Thus, in fig. 1, the "A" fleet, having the windward position, bears down in column (line ahead) before the wind and breaks through B's column (or "close hauled line ahead"). In the approach, fig. 1, A's leading ship or ships get the broadside of several of B's without being able to reply with more than a few bow guns, but the danger zone being small, and, once having an opening, the A fleet, fig. 2, goes through, raking B's nearest ships and doubling down the wing on his disorganized and confused formation. In an army on shore, on the other hand, line formation ("line abreast," as nautically expressed abroad,) must necessarily be the offensive formation, since men must shoot to the front, and hence "bow fire," so to speak, is the only fire. Troops advance on each other, delivering their maximum fire as they approach, and the tactical advantage is gained by turning the enemy's flank, and thus avoiding or "masking" the fire of his center and of his other flank (fig. 3). Military tactics are thus practically the reverse of those of the sailing ship period.

With modern battleships the installation of pairs of heavy guns in the ends of ships, and the introduction of the ram and the torpedo have changed naval tactics. Bow and stern fire is now a little less than 30 per cent. of each broadside fire, instead of about 5 per cent. as in the sailing ship days, and to attempt to break through an enemy's column, as in figs. 1 and 2, would be the height of folly. The leading ships of A, with less than 30 per cent. of their total fire available, would, in attempting to break through, be withered by the powerful concentrated broadsides of B's column, or destroyed by his torpedoes, or sunk by his rams. Then, too, raking fire has lost its terrors because the bow and stern presentation of a modern battleship is very strong owing to its concentration of heavy armor in the casemates, barbettes and turrets. In other words, at close quarters, a raking fire is not necessarily any more disastrous than firing at the broadside.

We thus have in modern steam-fleet tactics a sort of half way, or a compromise, on sailing ships and military tactics, for "to turn the enemy's flank," as in the army, is a good maneuver; the approach to the attack in line is now feasible, as it gives about 30 per cent. of gun-fire; and column, as in the past, is the formation giving maximum effective gun-fire. As stated before, the function of the gun is to destroy the battery and personnel, because armor and the watertight subdivisions make it well nigh impossible to reach the vitals of a ship with gun-fire alone, except with plunging fire at long range, and destruction is the function of the ram and the torpedo. (Incidentally, as will be shown later, it is the large port openings and failure to isolate the gun positions in most of our battleships that constitute sources of peril with an enemy that can shoot). To state the general proposition more in detail, with steam and modern improvements:

First, bow fire has become a great factor in modifying tactics.

Second, the ram is more than ever a dangerous and fatal weapon.

Third, armor has almost nullified the great danger from raking fire at close quarters.

Fourth, the torpedo has made it dangerous to fight at closer range than 1,000 yards.

Fifth, smokeless powder and high speed make the windward position of little importance compared with getting the sunlight on the enemy and in his eyes.

Sixth, elaborate subdivisions in ships tend to prolong the time and increase the difficulties of the destruction of a ship by any weapon.

To illustrate the relation between formations and the concentration of gun-fire, a series of diagrams are herewith appended. In the unit battleship, as in fig. 4, it is considered that a ship can bring her whole broadside to bear 45 per cent. forward or abaft the beam, and, for convenience, we will consider only one broadside at a time. The bow and stern fire is 30 per cent. of the broadside. With a number of ships in column as in fig. 5, the area of maximum concentrated gun-fire is abreast the middle ship and at a distance equal to half the length of the column. The nearest that ships can steam in column, and do anything else, is 200 yards interval, or "half distance," as we call it, and it is important to note that, in this case, with nine ships, the distance

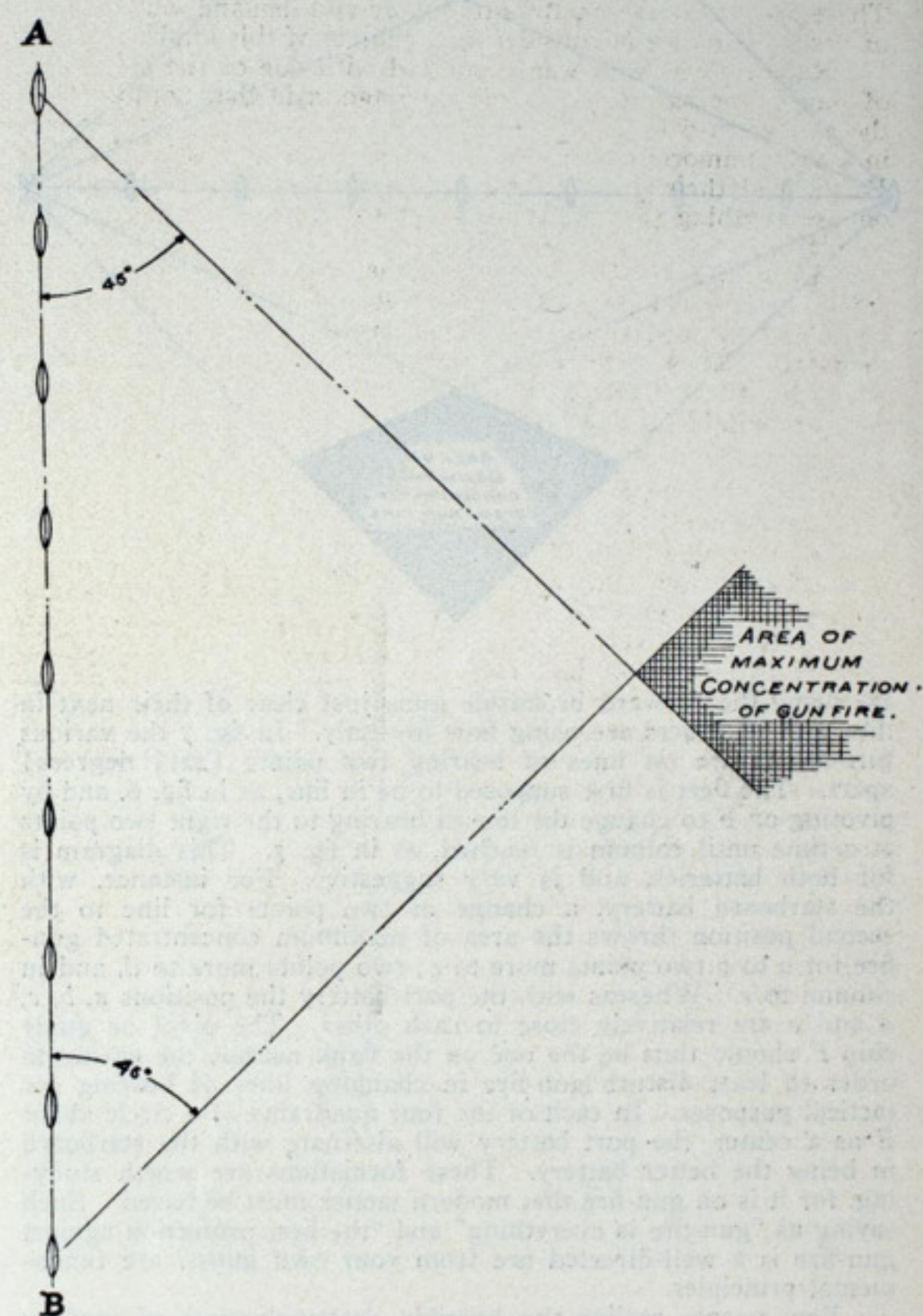


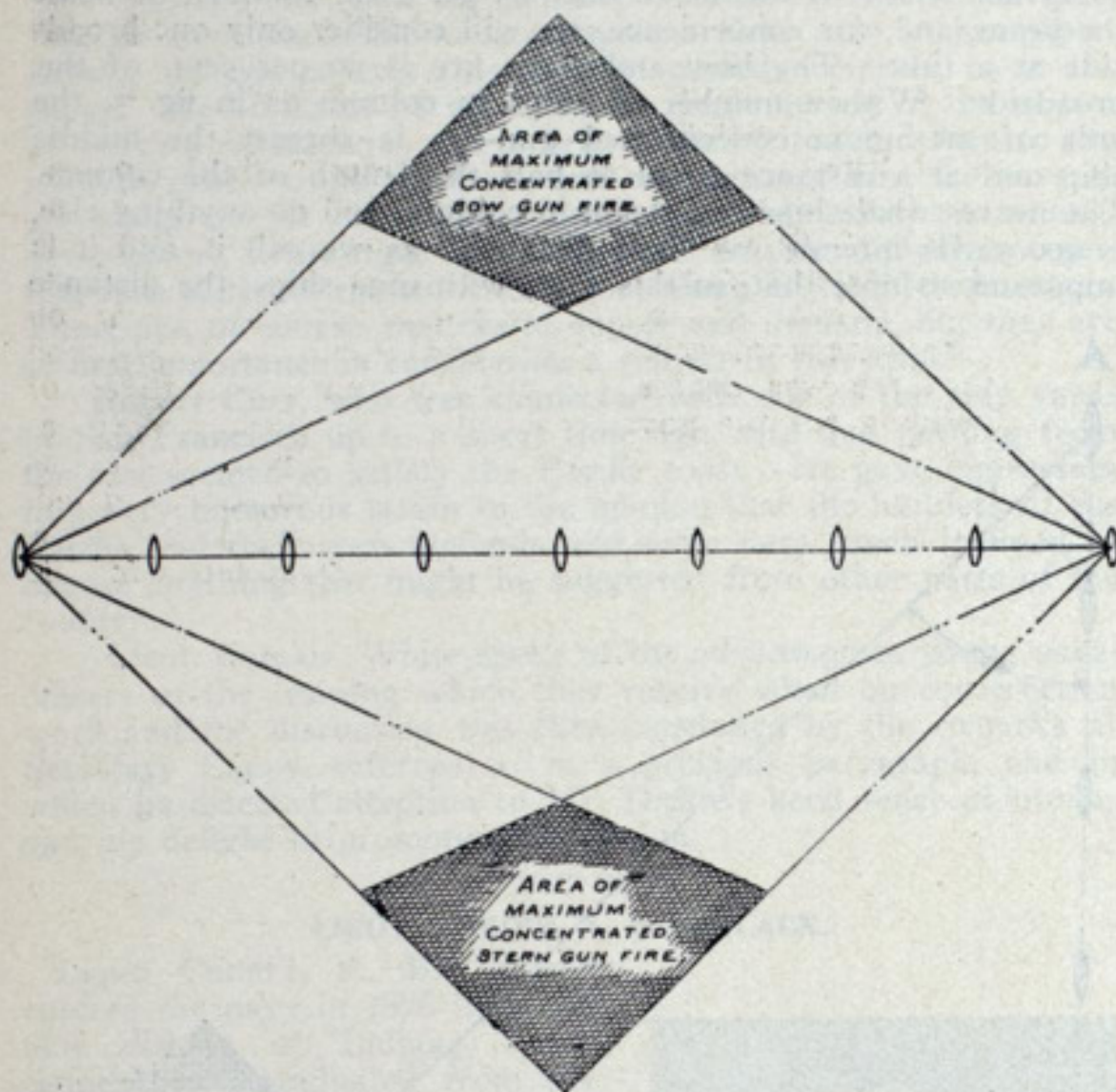
Fig. 5.

of the area of maximum concentrated gun-fire is 800 yards, which is quite easily within torpedo range today. I am personally mentally incapable of understanding the reasoning which has led the board on construction, in the navy department, to leave under-water discharge torpedo tubes out of the recently designed battleships and armored cruisers. (We have them only in the Maine, Missouri and Ohio, of all our ships in the navy). Every one regards above-water torpedo tubes, in such ships, even behind armor, as rather dangerous, but with, as I believe, the very best and safest under-water discharge system, and with either the new modified Obry or the Kaselowsky attachment fitted to torpedoes, it is inconceivable that any one can argue against under-water tubes for modern battleships. In fact, a ship is not a battleship unless she has them. I have personally seen under-water discharge abroad with our type of tube, and the modified Obry gear, with 1,000 yards run, in this country, and I have as much faith in the accuracy and reliability of the torpedo as I have in the 12-in. gun. Modern fleet tactics demand the torpedo. Its mere presence on board limits the range at which gun-fire may be used in single-ship actions or in fleet engagements, and just when the torpedo is beginning its development it seems to be a poor time

to dispense with it. A battleship disabled in her battery, but intact below the water line, is an ugly problem if her ram and torpedoes are also intact. She is still capable of sinking one or more battleships if desperately and skilfully handled. I repeat, it is a grave mistake to leave these tubes out of our ships, and I earnestly hope the secretary of the navy will intervene and save us from the results of this short-sighted policy. Twelve feet between bulkheads will give us ample space to operate a tube on each side, and as we may soon see torpedoes with 1,500 yards range, it behooves us to retrieve, as far as we can, our mistake in this particular.

In fig. 6 we see that the area of maximum concentrated gun-fire of a fleet in line is near the center ship. The two flank ships

Fig. 6.



are firing the forward broadside guns just clear of their next in line, and all others are using bow fire only. In fig. 7 the various formations are on lines of bearing two points ($22\frac{1}{2}$ degrees) apart. The fleet is first supposed to be in line, as in fig. 6, and by pivoting on F to change the line of bearing to the right two points at a time until column is reached, as in fig. 5. This diagram is for both batteries, and is very suggestive. For instance, with the starboard battery, a change of two points for line to the second position throws the area of maximum concentrated gun-fire for *a* to *b* two points more to *c*; two points more to *d*, and in column to *e*. Whereas with the port battery the positions *a*, *b*, *c*, *d* and *e* are relatively close to each other. The pivot or guide ship F should thus be the one on the flank nearest the enemy in order to least disturb gun-fire in changing lines of bearing for tactical purposes. In each of the four quadrants of a circle about F as a center, the port battery will alternate with the starboard in being the better battery. These formations are worth studying, for it is on gun-fire that modern tactics must be based. Such saying as "gun-fire is everything" and "the best protection against gun-fire is a well-directed fire from your own guns," are fundamental principles.

Few people realize the horrible destructiveness of modern gun-fire. Our fleet at Santiago accomplished what it did with less than 4 per cent. of hits, and at that time our navy had the reputation of having the best gunners in the world. Since then both ordnance and gunnery have been almost revolutionized, so much so that guns and methods good enough for 1898 are an invitation today to disastrous and bitter defeat. To illustrate how gunnery has improved and how terrible must be the hail of projectiles in a modern fleet engagement, let us briefly notice the recent progress made in the British navy in the matter of target practice. Let us take first the 6-in. guns, as shown by the annual prize firing contest for 1901.

Each ship steamed at a speed of twelve knots and fired for two minutes with each 6-in. gun, firing one gun at a time, at a target 20 ft. long and 16 ft. high, at a distance of nearly a statute mile. As published in the British press and verified by official reports, in 1901 the average of forty-eight British ships was nearly two hits per gun per minute. The best fifteen of the forty-eight made from two to four hits per gun per minute, but the best individual record was a string of eight shots and eight hits in one minute.

The record in the British navy for 6-in. guns for the year 1902, so far as published (and the record is, of course, not yet complete), is as follows:

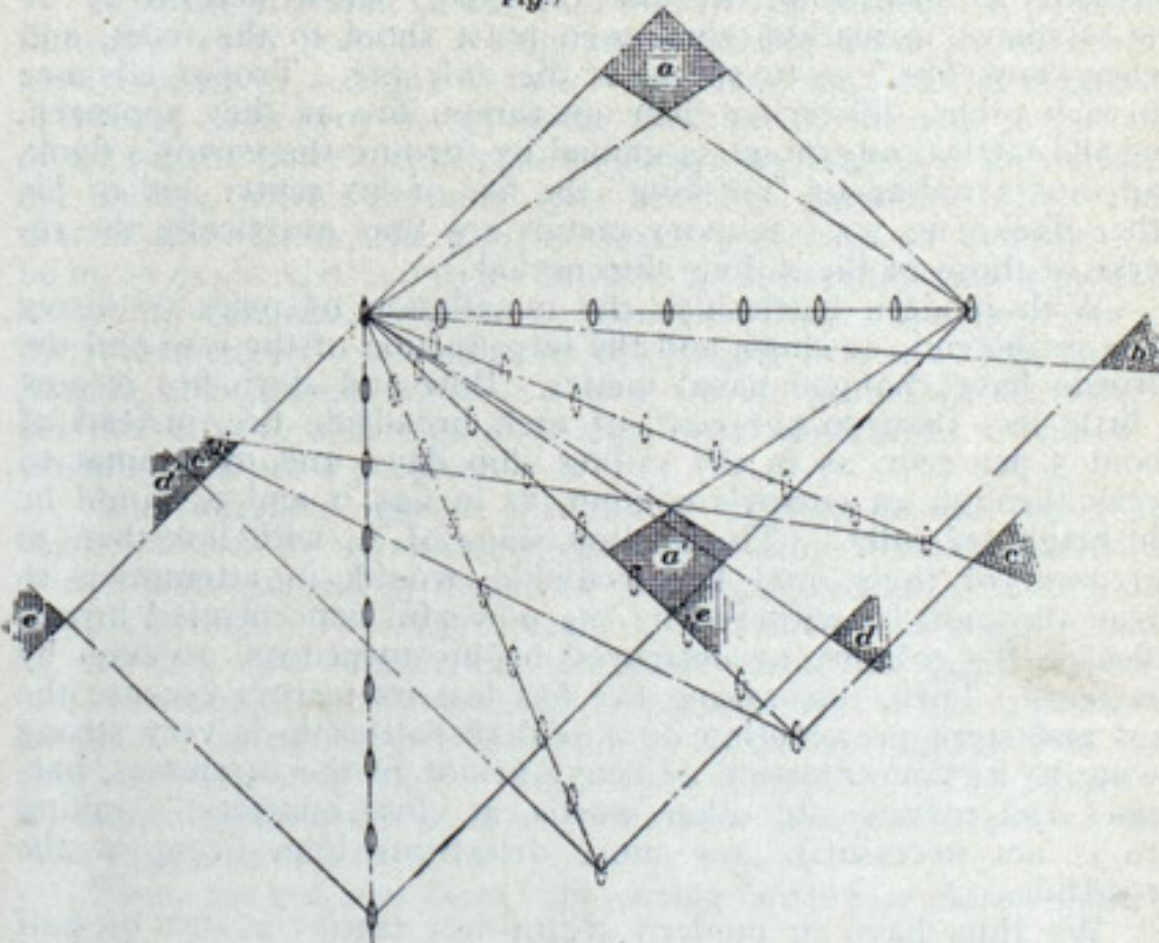
No. of guns.	Name of ship.	Shots.	Hits.	Per minute.		Percentage of hits.
				Shots.	Hits.	
12	Ocean.....	163	117	6.79	4.875	71
12	Crescent.....	139	105	5.79	4.375	74
12	Goliath....	163	71	6.79	2.958	49
12	Terrible.....	109	66	4.54	2.750	60
10	Blenheim.....	84	50	4.20	2.500	59
12	Albion.....	117	57	4.87	2.375	48
12	Cressy.....	92	52	4.83	2.170	56
Totals.....	82	867	518			

In other words, eighty-two 6-in. guns fired 867 projectiles in two minutes and made 518 hits, or nearly 60 per cent. The Ocean averaged nearly five hits a minute. One of her gun captains fired nine shots and made nine hits in one minute. This is easily the world's record, as it means less than seven seconds between aimed shots. One gun fired seventeen shots in two minutes and made fifteen hits. It will be seen that the percentage of hits does not determine the standing of a ship. It is the number of actual hits per gun per minute. In smaller caliber guns one ship, in 1901, fired 159 shots in one minute from her 4.7-in. guns and made 114 hits or 7.5 shots and 5.7 hits per gun per minute. In larger calibers the Ocean this year made 68 per cent. of hits with her 12-in. guns, and one ship in the British navy has a record of eight shots and seven hits with her 12-in. guns in five minutes and thirty seconds. Indeed, the established firing interval for British 12-in. guns is about forty-eight seconds.

It is very evident that since gun-fire is intended to put out of action the battery and gun's crews of other ships that the gun positions must be well protected against such fire as is now possible, and which we have apparently not reckoned on. Can we afford to let such ships as the Kearsarge and Kentucky remain as they are with such large port openings and with their 5-in. guns in open casemates? Even in the Alabama class, the gun-recoil cylinders are exposed to danger from small projectiles or fragments of shell. Must we not come to the foreign practice of mounting our 5-in. and 6-in. and 7-in. guns in closed or isolated casemates, each with its ammunition supply? In our newest ships, the turret mountings are excellent, but we have sacrificed in the smaller guns the question of protection to that of numbers. We have always given our ships heavier batteries than corresponding types abroad, and we have kept pace with the progress in initial velocities, but I am beginning to think that the Germans have pursued the safer course in keeping their guns of standard pattern and of smaller calibers and lower muzzle velocities.

The British are experiencing great trouble with their guns in the erosion due to the use of cordite, which is a nitro-glycerine powder. Cordite has the advantage over the nitro-cellulose powder which we use, in that the charges are 40 per cent. lighter than ours. This means quicker loading, for the charges weigh less and are shorter, and hence the shell is gotten home more quickly. In the British 6-in. guns the shell can be pushed home by hand. In ours, a hand rammer must be used. The Germans use a nitro-glycerine powder and they have no trouble from erosion. Our powder gives very much greater velocities than the British or German, but the charges are from 30 to

Fig. 7.



40 per cent. greater and our gas check pads are not all they should be to stand the pressures. We have recourse, however, to metallic gas checks, and our troubles are no greater than those of other countries in these respects. Just now the navy needs unusually and heavy expenditures for ordnance. Ships have been in continuous service from the pressure of the last five years, and every one of them needs to come to a navy yard and get a complete overhauling as to battery and particularly as to ammunition, as they have on board a heterogeneous lot of brown powder, smokeless powder and projectiles collected from various sources, most of it for the war with Spain. It is a pity we cannot meet the issue squarely and withdraw and destroy the whole lot, or at least get it into serviceable shape. We cannot hope to excel in

target practice when the powder charges and sights do not correspond, when misfires and delays occur from poor ammunition, and when the gun-mounts themselves are in need of thorough overhauling. The problem of brass cases vs. loose charges; of metallic vs. plastic pad obturation; of electric vs. percussion firing; of the form and mounting of the telescope sight, and of its graduation; of the rapidity of elevation and train of guns; of loading at any angle of elevation—all these are but a few of the pressing questions in ordnance. In training men to shoot we are baffled by the continual change in the personnel of our ships; in the strain on officers and men due to the undermanning of our ships; in the constant drive to make an inadequate number of ships constantly shift about all over the world to meet political and other emergencies which directly prevents target practice; and also by inadequate appropriations for gunnery exercises. For the current year the appropriation for gunnery exercises is \$12,000 for the entire navy. We are now asking for \$120,000.

The work of the navy is not in the least understood by the country at large, and it is difficult to make its needs adequately appreciated. In the war with Tripoli and in the war of 1812, the record of the navy was clear and unmistakable because the army did not figure. Few appreciate the part it played in the civil war in breaking the backbone of the rebellion by the blockade it maintained, and in its services in the inland waters, because it was overshadowed by the splendid work of the army. In the campaign in the Philippines the navy contributed largely to the ending of the war by the blockades it established, by the destruction of supplies and communications between the islands, and by its vigilant patrol of its long and broken coast line; but its services were not even mentioned in the recent amnesty proclamation, and the entire credit was given to the army. In the next war the navy must bear almost the entire brunt. There is a disposition in congress and in the country at large to let up on our naval expansion. History teaches the folly of such a course, and reason tells us that we are courting humiliation. We need more officers and men, the batteries of ships being the basis of computation, and the battleship and armored cruisers the unit. A good many of the so-called cruisers on our list are little better than junk for our purposes, and they should be replaced by ships designed for scouting and auxiliary purposes. Such ships as we improvised in the war with Spain will not answer in the next war. It is to be regretted that we have not a regular building program of battleships, but that is hoping for too much foresight.

In the study and formulation of the principles of tactics and strategy we may rest assured that the naval war college at Newport is alive to its responsibilities, and we may now confidently look forward to the day when a general staff will put the principles into execution in case of the appeal to arms to which this country seems to have the habit and for which it is apparently always unprepared. We cannot afford next time to trust to luck and an obliging enemy. There is a healthy realization in the personnel of our navy today of our unpreparedness, and of the fact that other powers know it. We know very well where we stand in the matter of target practice. We need during the coming year \$2,000,000 in ordnance and \$120,000 in "gunnery exercise," instead of the usual \$500,000 and \$12,000 respectively. "Gun-fire is everything."

LIEUT. COM'DR. NIBLACK'S PAPER DISCUSSED.

"We are much indebted to Mr. Niblack," said Admiral Bowles, "for the thoroughness with which he has described the essential purposes for which these ships are built. There is one point in his paper of which I wish to speak. He regrets that the submerged torpedo is omitted in the new design. I do not feel called upon to defend this omission. When the military officers agreed that it was not desirable to incorporate the submerged torpedo in the design of the new vessels you can imagine that as a constructor I was very glad to leave it out."

"Mr. Niblack's paper," said Lieut. Com'dr. White, "explains the reason for desiring ships of such large size. In actual combat the leading ship must bear the brunt of the attack. Her defensive properties must be great to resist the attack and her offensive powers great to defend herself. The concentration of fire is always on the nearest vessel; the leading ship is always the object of attack, and the naval warfare of the future is going to be like the game of follow your leader. The idea of singling out ships of the fleet for individual attack is pretty generally exploded. Mr. Niblack shows that the bow battery is 30 per cent. of the broadside. Any arrangement which would tend to increase that percentage would be desirable. The reason why 6-in. guns instead of 7-in. guns are placed on these cruisers is due to the fact that we can obtain sufficient penetration with the 6-in. gun to frighten any vessel we are likely to come in combat with; and the 6-in. gun has the added advantage of firing more rapidly and effectively. Mr. Niblack, I believe, puts too much weight on the effectiveness of the ram. It is entirely too dangerous to the vessel that has the ram. Both ships would be liable to go down. He also says that when the personnel is put out of action the vessel is still an element of danger. I believe it is generally concluded that when a certain percentage of the personnel is put out of action it seems to destroy the further efficiency of the ship. It acts as a shock and is too much for the crew to recover from—in the same sense probably that a blow in any part of the human body effects the whole of it."

MR. LAWRENCE Y. SPEAR.

Mr. L. Y. Spear is of Ohio birth. He was appointed to the naval academy in 1886 and graduated in 1890. After about a year's service, principally in South American waters, he was ordered to Europe for a special course in naval architecture. He was appointed assistant constructor in 1892. He returned from Europe in 1893 and was ordered to duty in the bureau of construction and repair at Washington. Later he served at the Union Iron Works, San Francisco, as assistant to the superintending constructor and at the Mare Island navy yard as assistant to the naval constructor. Then he was ordered to Seattle to superintend the construction of the torpedo boat Rowan at the works of the Moran Bros. Co. and to take charge of the construction department at the Puget Sound naval station. In 1898 he was promoted to naval constructor and ordered to Annapolis in charge of post graduate course in naval architecture. When this school was abandoned he went on duty at the bureau of construction and repair in Washington and from there was ordered as superintending constructor of vessels building for the government at Lewis Nixon's Crescen Ship Yard, Elizabethport, N. J., and at the ship yard of the Gas Engine & Power Co. and Charles L. Seabury & Co., Consolidated, Morris Heights, N. Y. He resigned from the navy July 1, 1902, to accept position as general manager and naval architect for the Holland Torpedo Boat Co.



Mr. Lawrence Y. Spear.

PAST, PRESENT AND FUTURE OF SUBMARINES.

Mr. Lawrence Y. Spear then read his paper upon "Submarine Torpedo Boats—Past, Present and Future." This paper was one of the most exhaustive and one of the best prepared—that is in the sense of showing thorough workmanship—of any presented at the meeting. While a lengthy paper the members were very glad to sit quietly in their seats and listen to the whole of it. It was a complete review in brief of the history of the development of the submarine boat. Mr. Spear's paper follows:

As the development of the submarine, although fairly continuous, has not been entirely orderly, no sharp line can be drawn between the past and present, and during the merging period the work of contemporaries must be arbitrarily classified. That period is here taken to include the years 1885 to 1891, inclusive.

The ever increasing importance of the submarine torpedo boat in naval warfare renders it desirable that this first communication should treat the subject exhaustively on the historical and descriptive side in order to clear the ground thoroughly for future communications and discussion. However, the investigators of the problems involved have been so numerous and their work has been spread over such a long period of time as to render anything like a full treatment here impossible on account of the limitations of space. Still the process of contraction need not squeeze out much that is of value, for, as Admiral Hichborn

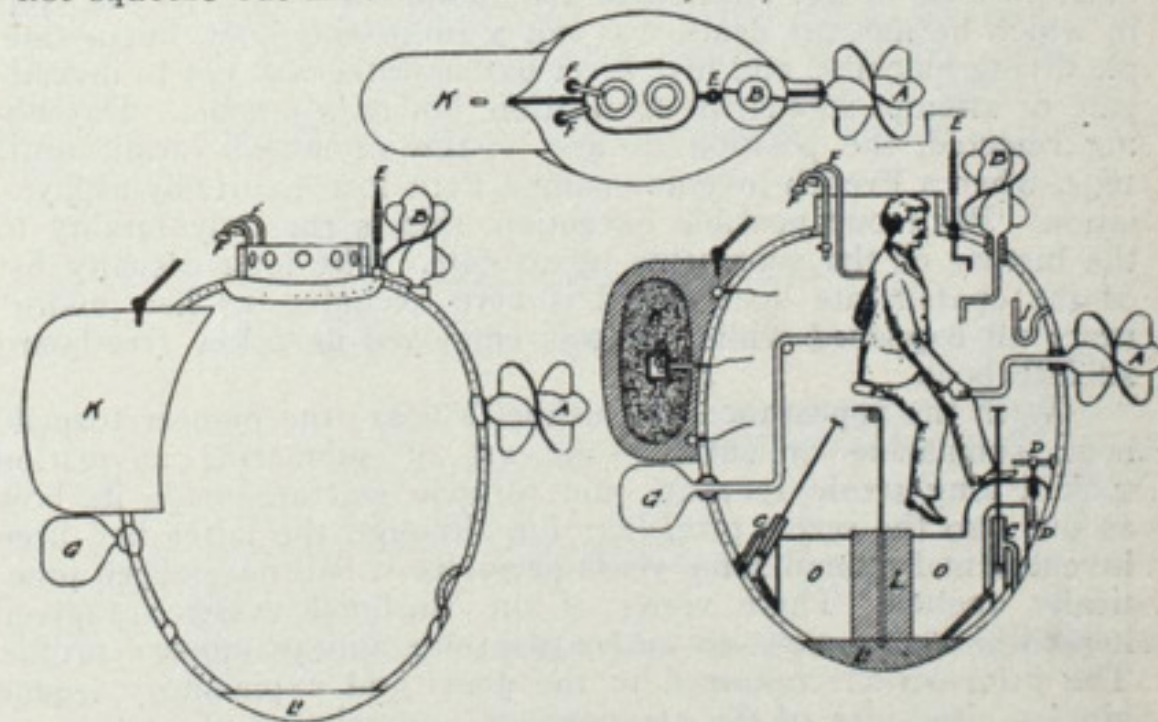


Fig. 1. Bushnell's Boat.

A, propeller; B, vertical propeller; CC, pumps; DD, flooding valve; E, torpedo screw; FF, ventilators; G, rudder; I, depth gauge; K, torpedo; L, ballast; L', detachable ballast and anchor; OO, ballast tanks.

has pointed out, a large number of inventors have neglected to read up their subject, and, proceeding *de novo* have embodied in their designs ideas and appliances already thoroughly tested by previous investigators. Most of these cases of reincarnation may be dropped without loss of perspective, as may also the greater part of the innumerable proposed submarine boats, of which none were ever laid down and not half attained the dignity of real plans. In the historical review to follow then, the proposed boats and reincarnations will be omitted except in a few instances where the mention appears to be justified by the prophetic nature of the proposal or by the historical aspect of performance,

and the examples selected for illustration will be limited, generally speaking, to the first of the most prominent types, either in point of time or importance.

Up to the seventeenth century man's work under water was apparently confined to experiments with crude forms of the diving bell. In 1624 Cornelius Von Drebbel, a Hollander, invented and built the first real submarine boat, oar propelled, and capable of obtaining a submergence of 15 ft. No reliable data as to the dimensions and construction of this boat are available, but history tells us that she could carry twelve persons, and was rendered habitable for a considerable period of time by the use of "quintessence of air"—probably compressed air or oxygen. The credit for the first boat is frequently given to an Englishman, Wm. Bourne, but there are good reasons for believing that his invention, which antedated Von Drebbel's, really belonged to the diving bell class. The history of the remainder of the seventeenth century and the greater part of the eighteenth, shows that little real progress, for, although some of the most important principles were grasped and recorded, the practical results achieved were unimportant. During the seventeenth century the center of activity remained on the continent of Europe, but in the following

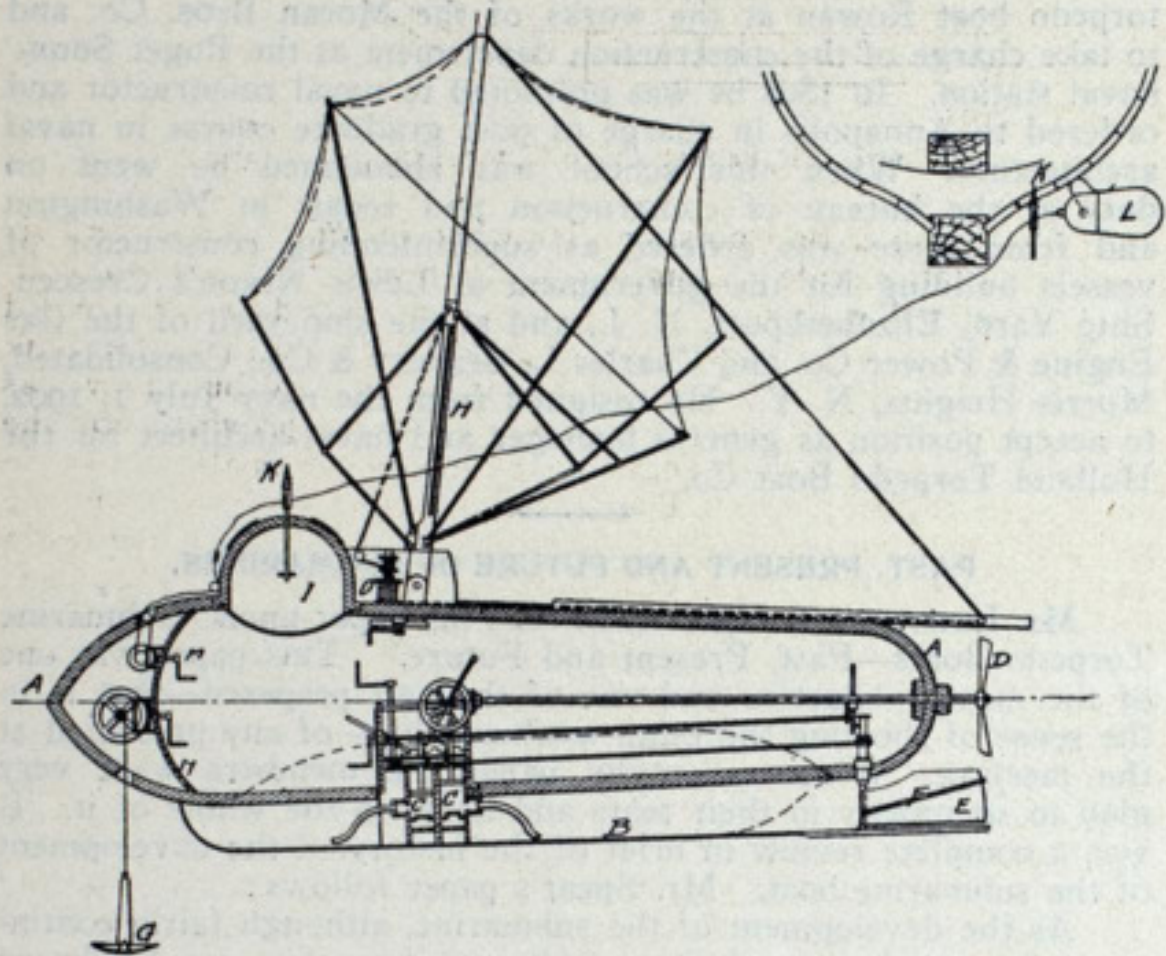


Fig. 2. Fulton's Nautilus.

AA, hull proper; B, hollow iron keel; CC, pumps; D, propeller; E, vertical rudder; F, horizontal; G, anchor; H, mast and sail; I, conning tower; K, torpedo spike; L, torpedo; M, gear; N, watertight bulkhead; O, mast gear.

century the problem received its principal attention in England and America, and from the latter country in 1775 came the first important solution, namely, Bushnell's boat.

On the intervening work it is unnecessary to touch here except to note that in 1772 the crushing of a submarine vessel by water pressure resulted in the death of its sole occupant, an Englishman named Day, who has long been heralded as the first victim of the submarine. On close inspection it appears, however, that he is not entitled to that doubtful honor, as the trap in which he met his death was not a submarine boat, but a simple diving machine, and his object under water was not to investigate or attempt submarine navigation, but to win a bet. Day being rejected, the position of first victim remained vacant until 1834, when a French inventor named Petit lost his life by asphyxiation. With one possible exception, this is the only fatality in the history of the submarine up to date. The long casualty list of the confederate boat David is here excluded, as her misfortunes all happened while she was employed as a low free-board surface boat.

With the appearance of Bushnell's boat—the pioneer torpedo boat, submarine or surface—the art of submarine navigation took a long stride forward, and torpedo warfare made its bow as did also the screw propeller, for although the latter had been invented in England some years previous, it had never been practically applied. Three views of the Bushnell vessel are given herewith, a plan view, an outboard profile and an inboard profile. The information contained in the plans and explanatory legend gives a clear idea of the arrangement and relation of parts, so it will only be necessary here to touch on the general features of the design which, all things considered, were well adapted to the purpose in view, namely, the attack upon ships at anchor. The form, a sort of flattened ellipsoid with the depth exceeding the length and the length exceeding the breadth, was suitable for the strength and stability required. The balance of buoyancy and weight was effected by the water ballast system in the bottom which also served as a compensating system for weights expended or received. A vertical screw, hand operated, controlled movements in the vertical plane, indicated by a depth gauge. The horizontal movement gained by a bow propeller, was controlled by an ordinary rudder on the stern, the vessel being steered when submerged by compass. The air supply when sealed up was sufficient to sustain for half an hour the one man required to operate the vessel, and was renewed upon coming to the surface

by exhaust and supply ducts with automatic operation. Lead ballast, detachable at the will of the operator, was fitted at the bottom, and was intended to be used as an anchor and emergency safety appliance. The armament consisted of a gunpowder torpedo a trifle larger than the water it displaced. This was carried on the stern of the boat and was intended to be attached to the hull of the enemy by a vertical detachable screw operated from the interior of the submarine. The release of the mine served to start the clock-firing mechanism which was set to admit of ample time for the submarine to clear the radius of explosion.

The fact is worthy of note that before building this vessel the inventor was required to educate his generation up to the possibility of exploding gunpowder under water, and the resulting destruction of floating bodies in the immediate vicinity, so that he was practically the originator of the modern fixed mine as well as of the torpedo boat. As to the qualities peculiar to the submarine it will be noted that efficient means were provided for varying the relation of displacement to weight, and it is possible that some reserve buoyancy might have been forced under by the vertical screw. Apparently, however, this was not the designer's intention, nor was the boat so operated, so she must be classed with the latter boats designed on the principle of equality of weight and submerged displacement.

BUSHNELL'S WORK TAKEN UP BY FULTON.

The fact that this boat never succeeded in blowing up an enemy's vessel, though she made three attempts, was due solely to bad luck. The only adequately trained operator fell sick before the opportunity for action presented itself, and the initial attempt was made by a half-trained man, who, starting from the New York shore succeeded in reaching unobserved a fifty-gun British ship lying off Governor's island. He attempted to fix his torpedo without anchoring and failed, as at the first attempt the screw struck an iron rudder hinge pad, and in seeking a new spot he lost the ship and was surprised by daylight before he could renew the attempt. Two subsequent attempts upon British ships occurred in the Hudson river, above New York, and were also disappointments on account of the operator's failure to use his anchor. Eventually lack of encouragement and funds put a stop to the enterprise.

The work thus abandoned by Bushnell was taken up shortly afterwards by Robert Fulton, who, in 1801, after some years of

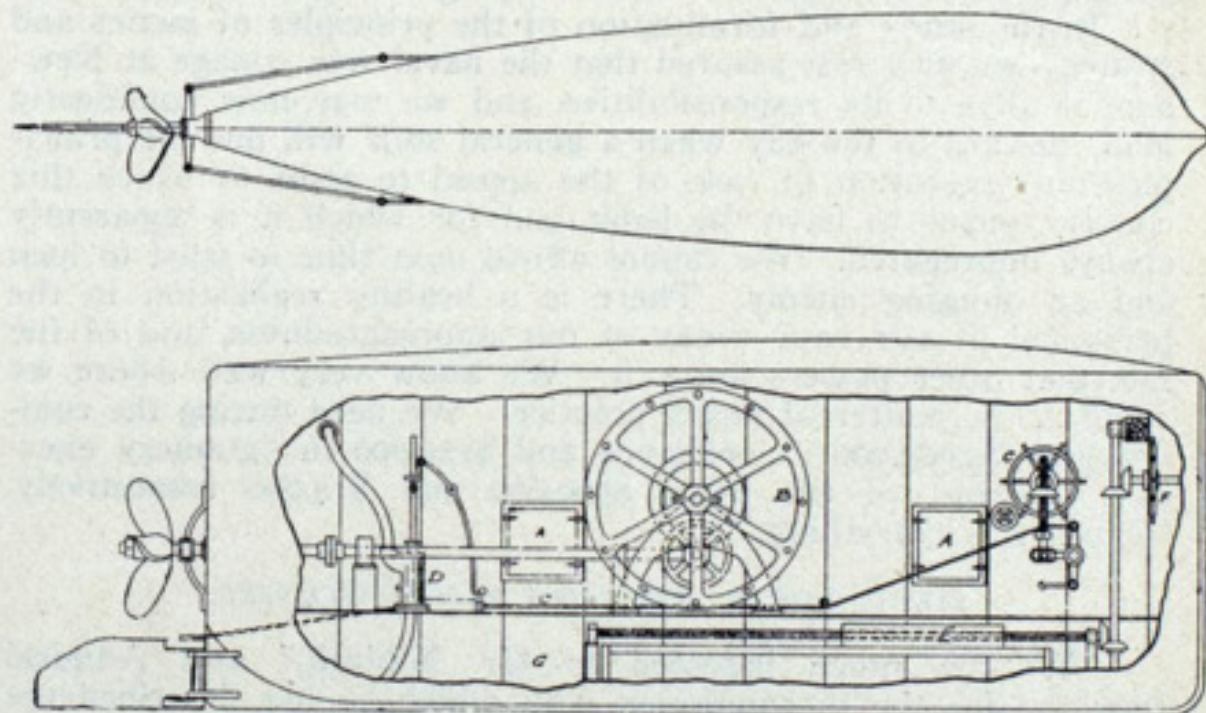


Fig. 3. Bauer's Plongeur-Marin.

AA, entrance hatch; B, driving wheel for screw; C, hand wheel for rudder control; D, pump for draining ballast tanks; E, trimming and diving weight; F, wheel for moving weight E; G, ballast tanks.

preliminary work, launched his first submarine, the Nautilus, into the Seine at Paris. This vessel, an imperfect ellipsoid in form—extreme length about 21 ft., extreme beam about 6 ft.—carried a hollow iron keel of a capacity equal to the reserve buoyancy in the light condition, which appears to have been very small. A double-cylinder suction and force pump controlled the water ballast carried in this keel. The anchor and torpedo gear were carried in a non-water-tight bow compartment, and both were operated from the interior of the boat. The vessel was navigated from a hemispherical conning tower fitted on the bow; an ordinary stern rudder controlled the motion in the horizontal plane and a pair of horizontal rudders were fitted at the stern for control in the vertical plane. Two methods of propulsion were provided—first, a hand-operated screw-propeller fitted at the stern, and second, a single mast and sail so arranged as to permit of folding and stowing from the interior of the boat. The propeller originally fitted consisted of a single convolution as did Bushnell's. This was later replaced by one of several blades, apparently the first propeller of modern form put to practical use. A compass and depth gauge completed the original equipment, which was augmented later by a pipe ventilation system and a crude compressed air system for breathing purposes only. The armament consisted of a gunpowder torpedo towed by the submarine and fired by contact. The plan of this vessel gives a clear idea as to the method of operating the torpedo and as to the general arrangement of the vessel. Eventually, Fulton and his crew of three men succeeded in remaining under water for a period of 4 hours and 20 minutes without ill effects. The

strength of the structure limited the depth of submersion to about 25 ft. The maximum speed under sail was about 2 knots and submerged about 3 knots. This vessel, like Bushnell's was designed for equality of weight and submerged displacement, and, as in the earlier vessel, this equality could be destroyed at will when necessary. The new features developed were the horizontal rudder, the double motive power, the conning tower and the compressed air system, all permanently established features of the best practice of today.

The Nautilus was subjected to thorough tests at Paris, Havre, Cherbourg and Brest, and the results of the tests were embodied in improvements until eventually she gave good promise of efficiency. However, the times were not yet ripe, and although Fulton and his projects created a furore, first in France and after-

ward, the control being regulated by an automatic pendulum mechanism. The proposals of this decade worthy of note here are those of Marie Davy and of Tetar Van Elven. The first suggested the electric drive and the second invented an optical tube for taking surface observations while submerged, which was the pioneer of the modern periscope.

The history of the crude American submarine employed in the civil war is well known, and, being practically devoid of technical interest, need not be recounted here, so that this short review of the submarine torpedo boats of the past may be brought to a close with a brief mention of four different types brought forward between 1860 and 1887, namely, the Plongeur of M. Brun and Bourgois, the early boats of Mr. J. P. Holland, the Nordenfelt and the Goubet boats. The first of these, the Plongeur, de-

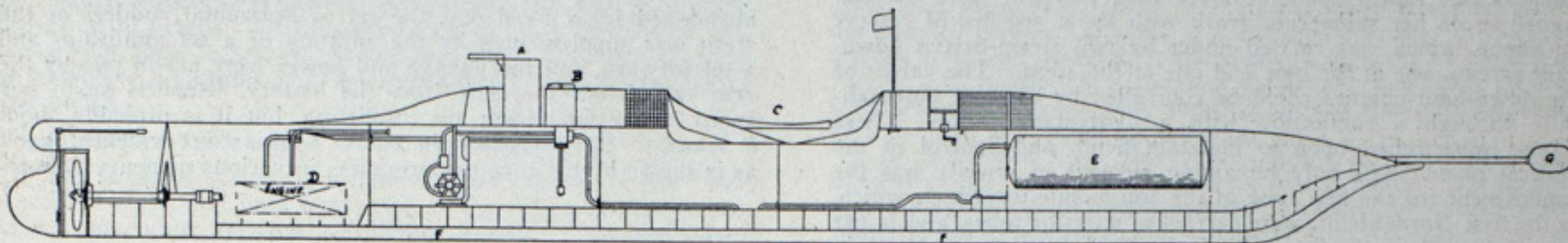


Fig. 4. Brun & Bourgois La Plongeur.

A, entrance hatch; B, diving regulator piston; C, location of lifeboat; D, engine; E, compressed air tank; FF, ballast tanks; G, torpedo.

ward in England, he failed to get his system adopted in either country, and eventually returned to the United States, where with congressional aid his experimental work was continued for some years, culminating in an experimental attack on the brig Argus, in which the Argus was victorious, though at the cost of rendering herself immobile by a system of spars and netting extending to the bottom. It is supposed that this experimental boat of Fulton's was the one employed in attacks on the British ships off New London in the war of 1812. These attacks forced the British commander to protect himself by the time-honored custom of hiding behind prisoners of war. The complaints and protestations of the relatives and friends of the latter had their desired effect, and the attacks were discontinued.

LITTLE PROGRESS DURING FIRST HALF OF THIS CENTURY.

With the exception of Fulton's work, the first half of the nineteenth century was nearly barren of practical results, but two proposals warrant mention here on account of the prophetic nature of the ideas advanced. The first proposal appeared in a letter from one M. B. in the *Annals of the Arts and Manufactures* in 1801, describing a submarine designed to work on the bottom. Two pairs of wheels were fitted fore-and-aft for this purpose, the wheels being driven by cranks, and assisted when desired by a propeller in the stern; later, about 1828, this idea was again proposed by M. Castera. The second important proposal appeared in 1823 and was published in the *Annales Maritimes*. This proposal contemplated an iron hull of large size, driven by a steam engine on the surface and a gas engine when submerged, and included a telescopic conning tower and submerged projectile tubes, surely sufficiently ambitious and scientific for the period.

The decade from 1850 to 1860 covers the work of the Bavarian, Wilhelm Bauer, who designed several submarines and built two—the Plongeur-Marin in Germany and the Diable-Marin in Russia. One of the illustrations shows the first-named vessel and, with the legend, is sufficient for descriptive purposes. Aside from the iron hull, the most interesting feature of this vessel

signed by Brun & Bourgois, and launched in 1863, was an experiment on a large scale. Length, 136 ft.; beam, 19 ft.; depth, 9 ft. She was armed with a spar torpedo and propelled by compressed air, which was also for the first time in history utilized for tank service. The final adjustment between weight and buoyancy was made by altering the latter, two pistons being provided for the purpose. The general arrangement of this vessel is also shown in one of the illustrations. The means provided for control in the vertical plane were entirely inadequate for a vessel of her form and dimensions, and her behavior was exceedingly erratic; later her equalities in this respect were improved by horizontal rudders, but her performance was still so uncertain as to condemn the type.

Mr. Holland's work began with a small one-man boat, built in 1877, which may best be described in the inventor's own words: "This boat, 14 ft. 6 in. long, 3 ft. wide and 2 ft. 6 in. in depth, was rectangular in external cross-section, and spindle-shaped inside, excepting in the middle section which accommodated the operator, clad in a diver's suit, and also a 4-H. P. petroleum engine in a separate water-tight space. The water ballast was held between the internal and external shells. Two small tanks at the sides of the central compartment held sufficient water to neutralize the reserve buoyancy. When the operator desired to leave the boat, the reserve buoyancy was first neutralized and then the water ballast was forced from the space between the shells into the central compartment around the operator, completely filling it, after which the man-hole could be opened without difficulty. Reserve buoyancy was provided for and submersion was obtained by midship rudders."

The action of the submerging apparatus was not satisfactory, and in the next boat—length, 31 ft.; diameter, 6 ft.; displacement, 17½ tons; finished in 1881—midship rudders were replaced by horizontal stern rudders. The experiments with this boat covered some three years, and the results attained demonstrated the practicability of forcing reserve buoyancy under by power from the propeller, the necessary inclination of the axis of the boat being obtained and controlled by rudder action alone. Contin-

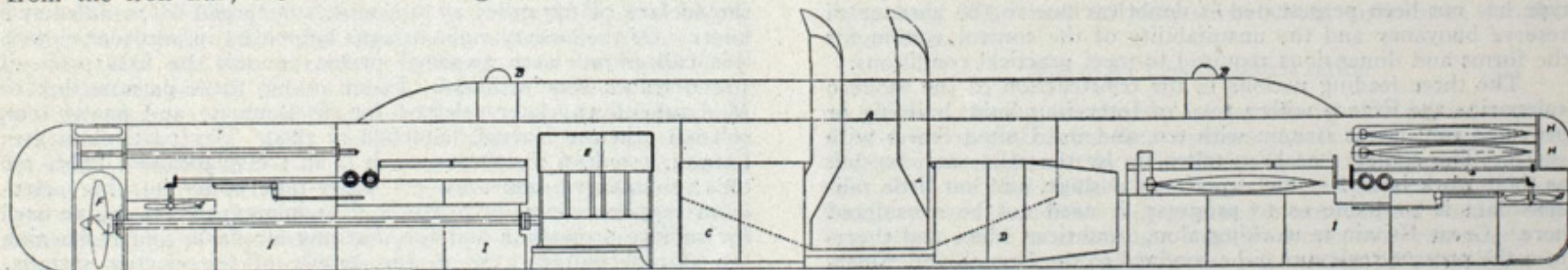


Fig. 5. Nordenfelt, No. 4.

A, entrance hatch; BB, conning tower; C-D, boilers and reservoirs for hot water; E, engine; F, screw; GG, vertical screws for trimming and diving; HH, torpedo tubes; II, ballast tanks.

ued development along these lines, both here and abroad, has produced the only successful and practical boats now existing. The Nordenfelt submarines are principally useful as examples of what to avoid, but merit some attention here, partly on account of the ambitious nature of the designs and the attention they attracted, but principally by reason of the false conclusions drawn by the inventor from his experience, which conclusions variously and ingeniously misstated have served to hamper materially the development of the submarine along proper lines. Nordenfeldt's attention was directed to the subject by a study of the work of an Englishman named Garret, with whom he later became associated, and the distinguishing feature of Garret's second boat was adopted in all of Nordenfeldt's designs, namely, steam propulsion, both on the surface and submerged; in the latter case steam being drawn from super-heated water, partly contained in the

was the method adopted for steering and controlling in the vertical plane, the first real application of the principle of the longitudinal shift of weights. Her trials were fairly successful and she succeeded in breaking up the blockade of Keil by the Danish fleet. On account of the collapse of the stern under water pressure, she was eventually sunk in some 60 ft. of water, the inventor and his crew escaping after an imprisonment of some hours. She has recently been located and raised and is now on exhibition at the naval school at Keil. In Bauer's second vessel, the Diable-Marin, longitudinal shifting of weights was supplemented by horizontal rudders, and an air lock for the egress of divers was provided. An American contemporary of Bauer's named Phillips, who experimented on the great lakes with a boat of considerable size, furnished the first example of automatic control in the vertical plane. This was effected by shifting water ballast fore-and-

boiler used for surface work and partly in special tanks. An in-board profile of the last Nordenfeldt No. 4, built in England, sold to the Russian government, and lost on the coast of Denmark while making the passage under her own power, is also shown in one of the illustrations. This vessel had a length of 125 ft., a light displacement of 160 tons, and a submerged displacement of 245 tons. With 150 lbs. of steam her engines indicated 1,000 H. P. Her estimated speed was 15 knots on the surface in the light condition and 5 knots submerged. In the latter condition the radius of action was expected to be 20 knots. Coal was employed as fuel, and the bunker capacity was sufficient for a radius of action in the light condition of about 1,000 miles at a speed of 8 knots. By employing some of the ballast tanks as bunkers this radius could be more than doubled. She was designed to do her submerged work with about 500 lbs. of reserve buoyancy, which was carried under by two steam-driven down-haul screws, one at the bow and one at the stern. The valves of the down-haul engines could be controlled by hand or automatically through a connection with a hydrostatic piston. These screws were relied upon to maintain depth and control in the vertical plane. The only remaining element of novelty was the employment for the first time of the automobile torpedoes, which, in the first Nordenfeldt, were carried in exterior tubes, and in the one illustrated, in the internal tubes. The trials of this No. 4 in the light condition were satisfactory, but as a submarine boat she was almost a total failure, as the down-haul screws proved inadequate to prevent yawing, so that when under water she, like the Plongeur, took charge and alternately sought the surface and the bottom, duplicating in this respect the behavior of the three previous vessels.

PRINCIPAL DEFECT OF NORDENFELDT'S DESIGN.

The principal seat of difficulty in all the Nordenfeldt boats was undoubtedly the large free liquid surface in the various tanks, resulting in a shifting center of gravity and a serious decrease of the designed stability. Large tank capacities were a necessary feature of Nordenfeldt's design, but the bad features thereof could have been largely reduced by subdivision. In No. 4 at least the inherent defects of the design in this respect were aggravated by mistakes in calculation, resulting in natural trim by the stern. This was corrected by an amount of fixed ballast forward, so great that certain of the ballast tanks could not be entirely filled without overrunning the permissible weights. These vessels were designed to maintain the horizontality of their longitudinal axis at all times—sinking, rising and running submerged—and most signally failed to meet expectations in that respect, as had previously boats of similar form designed on the same principle. Notwithstanding this, and neglecting the partial successes of predecessors working along different lines, Nordenfeldt continued to maintain the absolute necessity of this property. His dogma in this respect was widely accepted and so tenaciously held that some of its supporters continued until a very recent date to prove theoretically to their own satisfaction the utter impossibility of accomplished and widely known facts.

The last type selected for illustration was designed by M. Goubet in 1885, and began her trials in 1889. An inboard profile of the vessel with explanatory legend is among the illustrations. None of the main features of the design, namely, equality of buoyancy and weight, control in the vertical plane by the automatic longitudinal shift of water ballast and a steering propeller, were really novel, but it merits attention as the most successful example of its class. The small experimental boat proved successful on trial, thanks to the care taken with details; note, for instance, the minute subdivision of the ballast tanks. That the type has not been perpetuated is doubtless due to the absence of reserve buoyancy and the unsuitability of the control system for the forms and dimensions required to meet practical conditions.

The three leading nations in the construction of the modern submarine are France with a total of forty-four built, building or provided for; Great Britain with ten, and the United States with seven. The subject has been taken up by the other nations, but as their work is still in the experimental stage, and but little reliable data is available as to progress, it need not be considered here. Great Britain is working along American lines, and therefore the present review may be confined to the French and American boats.

The French fleet of modern submarines dates from 1886, when the then minister of marine, Admiral Anbe, ordered the construction of an experimental boat the *Gymnote*—length, 59 ft.; diameter, about 6 ft.; displacement, 30 tons—from the joint design of Dupuy de Lome and Gustave Zede. Her spindle-shaped hull was constructed of steel throughout, tank service was obtained from electrically driven pumps, and also from a compressed air system, which, in addition, furnished air for breathing purposes. A telescopic conning tower was provided for observation on the surface, and an optical tube for use below. The power installation consisted of a storage battery and a 55-H. P. motor driving a single screw. The reserve buoyancy was driven under from the propeller by inclining the axis of the boat, a pair of horizontal stern rudders being provided for that purpose. The trials beginning in 1888 were very exhaustive, and led to the removal of the telescopic tower and a number of other alterations, principally in the propelling and diving gear. Eventually satisfactory results were obtained at a submerged speed said to be 6 knots.

The *Gymnote* was followed by the *Gustave Zede*, ordered in 1890 from the designs of M. Romazzotti, and launched in 1891. The design followed closely that of the original *Gymnote*, but on a much larger scale, the dimensions being: Length, 159 ft.; diameter, 12 ft. 4 in.; submerged displacement, 266 tons. The hull was of bronze throughout. She was fitted with a single screw, driven by two 360-H. P. motors, fed by a storage battery of 720 Laurent Cely cells. She carried three Whitehead torpedoes and one bow tube. The step from the *Gymnote* to the *Zede* proved too large a one and extensive trials and many alterations were necessary before the *Zede* gave satisfaction. Evidently the designer of the *Zede* did not take full advantage of the data derived from the *Gymnote*, as the alterations in the two cases were along the same lines. The telescoping conning tower was abandoned for a fixed one, the set of horizontal rudders at the stern was supplemented by the addition of a set amidships and a set forward, and the voltage and power were cut in two by the removal of half the cells from the battery. Reports as to her speed in her final form are conflicting, but it is probably about 8 knots. Her behavior in other respects is evidently good as is shown by her own performances in various maneuvers, note-

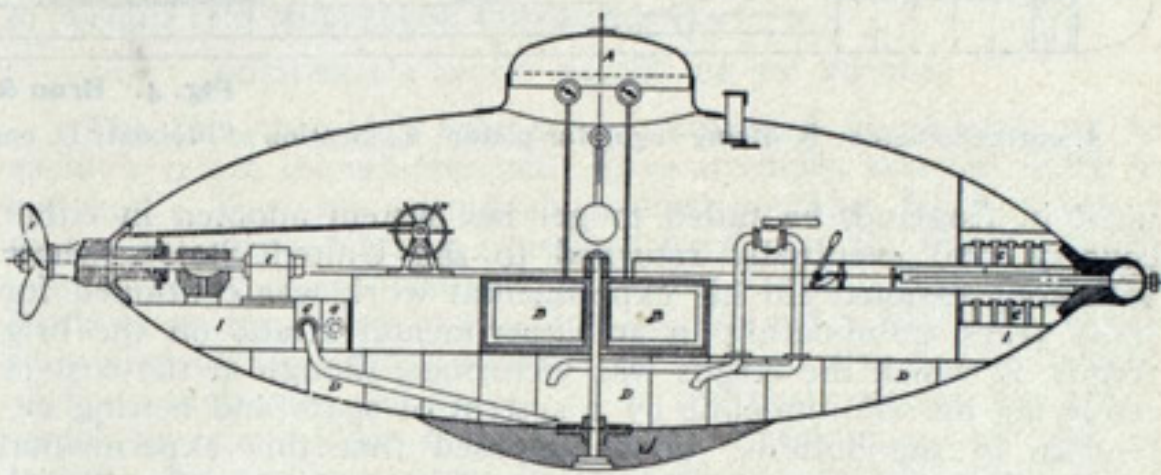


Fig. 6. Goubet.

A, conning tower; BB, compressed air tanks; CC, storage batteries; DD, ballast tanks; E, motor; F, adjustable screw; GG, pumps; H, wheel for adjusting screw; I, trimming tank; J, detachable weight.

worthy the torpedoing of the *Martel* in the harbor of Ajaccio during the maneuvers of 1901. Even while the *Zede* was building, it was apparently realized that her dimensions were extreme for the type, and an intermediate vessel, the *Morse*, was ordered from the plans of M. Romazzotti. Her particulars are as follows: Length, 118 ft.; diameter, about 8 ft. 6 in.; displacement, 146 tons; horse power, 350; armament, one bow tube and two side carriers of the Drzewiecki type. The design follows very closely that of the improved *Zede*. Her construction was long delayed on account of proposed improvements, and she was not launched until 1899. On trial she developed a speed of 12.3 knots on the surface and about 8 submerged—excellent results for her type. While the *Zede* and *Morse* were in hand, a different type known as the submersible and represented by the *Narval* was under development. This type is fitted with a separate power installation for propulsion on the surface and for recharging batteries, thus rendering the boat independent of a base so far as power is concerned, greatly increasing the radius of action and diminishing the risk of total disability.

THE MODERN FRENCH SUBMARINE.

In 1896 the minister of marine invited designs for a submarine not exceeding 200 tons displacement, which should carry two torpedoes ready for launching and have a radius of action on the surface of 100 miles at 12 knots; submerged of 10 miles at 8 knots. Of the twenty-eight designs submitted in accordance with this call, three were awarded prizes, though the first prize of 10,000 francs was withheld. From among these designs that of M. Laubeuf was later selected for development and finally took substance in the *Narval*, launched in 1899. Her particulars are: Length, 111 ft. 6 in.; beam, 12 ft. 4 in.; displacement, light, 106 tons; submerged, 200 tons. A water-tube boiler burning petroleum supplies steam for a 250-H. P. triple-expansion engine used for surface propulsion and for charging air flasks and recharging the storage battery. As to the details of the electric installation, little is known except that two motors are employed. The armament consists of four torpedoes in Drzewiecki carriers. The speeds and radii of action are reported to be as follows: Maximum surface speed, 12 knots; radius at that speed, 242 miles; radius at 8 knots, 625 miles; maximum submerged speed, 8 knots; radius at that speed, 25 miles; radius at 5 knots, 70 miles. As to submarine qualities, the design of the *Narval* follows the *Morse*, and aside from the double power installation the only item of particular interest is the construction adopted for the hull, which is a development of the system employed in the first Holland boat, namely, complete double bottoms or rather double skins, the enclosed space being entirely full of water when submerged. The French authorities appear to be well satisfied with the *Narval*, except as to the length of time necessary to pass from the light to the diving condition, which is excessive. In later boats of her class that time has been reduced somewhat—but the fault has not been wholly eradicated.

The exact composition of the total authorized fleet of forty-four cannot now be told, as the details of a number of the boats authorized have not yet been settled, and the experience with the

vessels in hand is certain to alter the program, probably in the direction of increasing the "submersibles" at the expense of the "submarines" proper. However, following the Morse, six submarines proper have been launched—the Francais and Algerien, which are almost identical with the Morse, and the Farfadet, Gnome, Korrigan and Lutin, somewhat larger. Particulars of these four larger vessels are: Length, 135 ft. 8 in.; diameter, 9 ft. 6 in.; displacement, 185 tons; surface speed, $12\frac{1}{4}$ knots, submerged speed, 9 knots. Twenty smaller vessels of the Perle class have been laid down. The particulars of these are: Length, 77 ft.; diameter, 7 ft. 6 in.; displacement, 70 tons; surface speed, 8 knots; submerged speed, 6 knots. Of the "submersibles" four have been launched and completed in addition to the type boat, the Narval. The four completed are the Sirene, Triton, Espadon and Silure—identical in general design with the Narval, but improved as to details. Of the "submersibles" now in hand or projected, but little is known, except that in at least one of them an explosive oil engine is to be substituted for the steam engine and boiler.

AMERICAN SUBMARINES ARE IN THE SUBMERSIBLE CLASS.

The modern American submarines all belong in the "submersible" class, and date from 1895, when the navy department, after competition, selected a Holland design and entered into a contract with the Holland Torpedo Boat Co. for the original Plunger. The history of that vessel is so well known that it will only be necessary here to recall to mind her principal features, which were: Length, 85 ft.; diameter, 11 ft. 6 in.; light displacement, 140 tons; submerged displacement, 165 tons. A petroleum-burning boiler furnished about 1,500 H. P. which was divided between two screws. A storage battery and motor were provided for submerged work. She was designed for 15 knots on the surface and 8 knots submerged, and was fitted with down-haul screws to assist her horizontal rudders. This combination was never put to a practical test, as the enormous steam power installed in a very limited space rendered her practically uninhabitable on account of the high temperature developed. Her construc-

with both hand and automatic control, were originally provided. These have since been removed and a simple and efficient hand gear has been substituted therefor. She carries one bow tube and five short Whitehead torpedoes with water compensation. The engine and motor are so geared up that either can be used to operate the auxiliary machinery which comprises an air compressor and a powerful rotary pump. The compressed air capacity for torpedo and tank service is 40 cu. ft. at 2,000 lbs. pressure, suitably reduced for various uses. The change in the relative power of the engine and motor is a large step in advance over the original Holland, as it enables fair speed, 6 knots, on the surface, to be made while charging batteries. Her speed and radii of action are as follows: In the light condition under the gasoline engine, 400 knots at a speed of $8\frac{1}{2}$ knots and 560 knots at a speed of 6 knots; in the semi-awash condition under the gasoline engine, 340 knots at a speed of 7 knots; in the submerged condition under the electric motor, 21 knots at a speed of 7 knots and 35 knots at a speed of $5\frac{1}{2}$ knots; and ready to dive with the conning tower only showing she has a maximum radius of 100 knots at a speed of 3 knots.

In November, 1901, this vessel with a full crew was submerged at her dock for a period of fifteen hours. During this time the only fresh air supply was that furnished by a leaky valve, which allowed the pressure in a flask of 5 cu. ft. capacity to run down from 2,000 to 1,90 lbs. per square inch. When the vessel was opened up the air was still reasonably sweet and pure, and the crew suffered no unpleasant effects. Her habitability under service conditions was tested last spring by a voyage under her own power from New Suffolk, Long island, to the Delaware breakwater. The first leg of the journey, from New Suffolk to New York, was made through Long Island sound at an average speed slightly exceeding 8 knots. The second leg, from New York to the Delaware capes, was made under half power at an average speed of 6 knots, except for an hour and a quarter during the journey which was occupied by submerged runs. Her ultimate destination on this trip was Chesapeake bay, but the voyage was brought to an abrupt termination at the Delaware

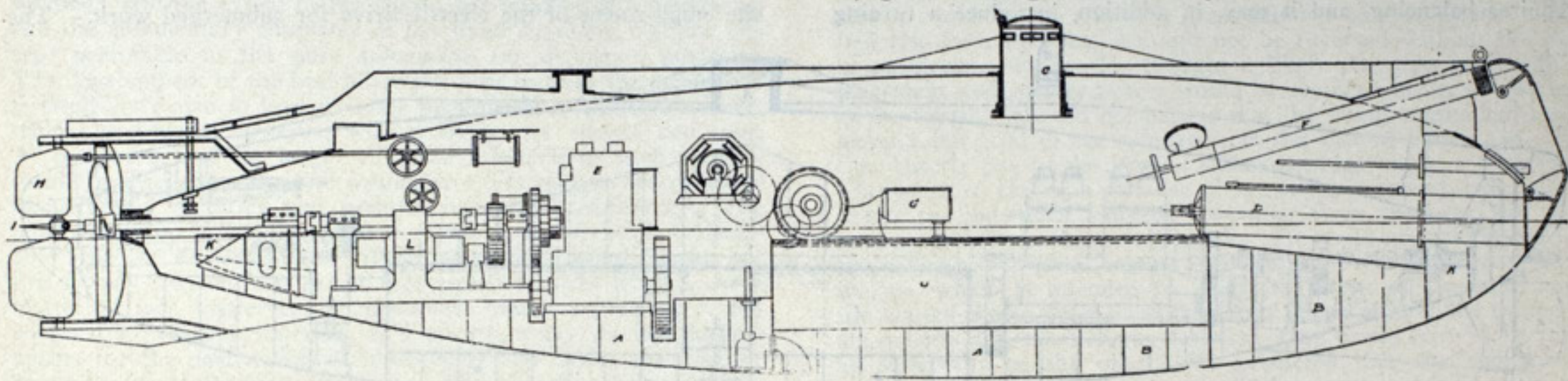


Fig. 7. The Holland.

AA, ballast tanks; BB, gasoline tank; C, conning tower; D, expulsion tube; E, gas engine; F, dynamite gun; G, air compressor; H, steering rudder; I, diving; J, battery tank; KK, trimming tanks; L, motor.

tion was eventually abandoned and a contract was entered into for a new Plunger of a truly modern type.

While the old Plunger was under construction for the government the same company brought out privately the Holland, length 53 ft. 10 in. diameter 10 ft. 3 in. submerged displacement 75 tons. She was propelled on the surface by an Otto gasoline engine of 50 H. P. and when submerged by a 50-H. P. electric motor fed by a storage battery of sixty cells with a capacity of 1,500 ampere hours at a four hour rate of discharge. A double commutator was fitted on this motor so that 150 H. P. could be safely developed. Her final armament consisted of one bow torpedo tube, one bow pneumatic dynamite gun and three short Whitehead torpedoes. Her surface speeds are 6 knots under the gasoline engine and about 8 knots under the motor, and her submerged speed is $5\frac{1}{2}$ knots under the motor. A single pair of horizontal rudders at the stern, operated by air engines, serve to control her in the vertical plane. These engines as well as the vertical rudder engines were arranged for automatic operation when desired, but experience has proven the entire feasibility of brain control, and the automatic attachments are seldom, if ever, used. Air compressors and reservoirs furnish air for the steering and diving engines, tank and torpedo service, as well as for breathing purposes. The reserve buoyancy resides in the conning tower, which was originally telescopic, but is now fixed. An inboard profile of the Holland is included among the illustrations.

In 1901 the same company brought out the Fulton, built as a trial vessel for the seven government boats Adder, Moccasin, Porpoise, Shark, Grampus, Pike and Plunger, for which contracts were entered into in 1900. The general features of the Holland's design have been followed closely in her, but she is larger, roomier, faster, and is simplified and improved as to details. Her particulars are as follows: Length 63 ft. 4 in.; diameter 11 ft. 9 in.; total displacement, $122\frac{1}{2}$ tons. On the surface she is propelled by a 160-H. P. four-cylinder Otto gasoline engine, and when submerged by a 70-H. P. electric motor fed by a storage battery of sixty cells, with a capacity of 1,900 ampere hours at a four-hour rate of discharge; average potential 110 volts. Pneumatic engines for the steering and diving rudders, the latter

breakwater by an explosion of battery gas, which had been allowed to accumulate underneath the battery deck. The presence of the gas was due to deterioration of the battery caused by accidental submersion in salt water. An inboard profile of the Fulton will also be found among the illustrations. The government boats Adder, Moccasin, Porpoise, Shark, Grampus and Pike are practically duplicates of the Fulton. The Plunger is the same in dimensions and general arrangement, but differs in some details, the most important of which is the armament, where three long Whitehead torpedoes have been substituted for five short ones.

THE LAKE TYPE OF SUBMARINE.

Before closing the descriptive portion of this paper, mention should be made of another modern American submarine, the Argonaut, brought out by Mr. Simon Lake. The Argonaut herself does not fall within the scope of this paper, as she was designed for commercial purposes and is not adopted for torpedo-boat work. She is entitled to mention here, however, partly on account of her interesting features, but principally on account of the fact that her inventor is building an experimental boat embodying her principal features, but intended also for torpedo-boat work. The approximate dimensions of the Argonaut are as follows: Length 36 ft.; diameter 9 ft.; displacement submerged, 60 tons. Her under-water work is confined altogether to operations on the bottom. A 30-H. P. gasoline engine propels her on the surface by a single screw, and on the bottom by this screw or a pair of driving wheels, or both, as desired. The guide wheel serves as a rudder, both on the surface and submerged. In common with other submarines, she has a water ballast, compressed air and electric light system, which present no novel features except as to the bow searchlight for examination of the bottom. She is submerged by down-haul weights of 1,000 lbs., attached to suitable windlass mechanism by which any amount of reserve buoyancy not exceeding the down-haul weights may be hauled under. The water ballast system enables the relation between the down-haul weights and the reserve buoyancy to be altered at will, so that the virtual weight on the bottom may be controlled. Communication with the surface is always retained by two hol-

low masts, which form ducts for the introduction of air and the expulsion of the products of combustion. As the vessel was intended for submarine surveying, wrecking, etc., a diver's compartment and air lock is made a prominent feature of the design. The success of this vessel in her field has led the inventor to place on the stocks a new and larger vessel, in which it is intended to combine the bottom-working features of the Argonaut with the necessary properties for operation between the surface and the bottom. This vessel is to be fitted up with a storage battery and motor, so that communication with the surface need not be retained. The apparatus for controlling between the surface and bottom will consist of inclining planes fore-and-aft, termed by the inventor "hydroplanes." The design contemplates great stability, the intention being to maneuver on an even keel, the hydroplanes serving simply to give a vertical thrust but no turning moment about the center of gravity. At the time of writing, this vessel has not been launched, so no data is available as to the efficiency of the design, except in so far as it duplicates the Argonaut.

FUTURE OF SUBMARINE TORPEDO BOAT CONSTRUCTION.

Before attempting to foreshadow the future of submarine torpedo-boat construction, it will be desirable to examine in a little more detail the more important features of the modern types, as such examination, though necessarily brief, should enable us to judge roughly both as to the propriety and possibility of future development along the present lines. Confining ourselves at present to the *submersible* type, we note that the French and American designs, though independently worked out are identical as to general principles and close to each other in the main features of design, the difference in the aims of the designers being taken into account. The distinguishing features of submarines are, first, reserve buoyancy, and second, control in the vertical plane by rudder action only. The presence of reserve buoyancy undoubtedly increases the difficulty of securing complete and satisfactory control in the vertical plane, as no matter where located it introduces an upward form which requires balancing, and it may, in addition, introduce a turning

American using the light oil gasoline, with an explosive engine while the French employ a heavier oil, petroleum, and transform its energy into steam instead of using it direct in an explosive engine. From a purely theoretical point of view, the American system is better adapted to the purpose, involving as it does only one variable weight, fuel, against two for the other, fuel and feed water. This leads directly to simple and rapid compensating arrangements tending towards a reduction in the time necessary to pass from a cruising to the fighting condition, a tendency still further helped by the absence of the high temperature accompanying steam propulsion, as well as the slow working apparatus for the escape of the products of combustion. In general simplicity and economy of space the American system offers additional advantages. On the score of safety, the advantage, if any, lies at present with the French. A less volatile oil is used in the first instance, and it is probably less difficult to secure the complete expulsion of the products of combustion. The advantage, however, is not important as the danger element in either case is well within permissible limits and will undoubtedly be still further reduced in future boats employing the American system by the use of heavier oils and the perfection of the apparatus for disposing of the products of combustion. The principal advantage of steam propulsion lies in the fact that the designer can avail himself of very complete data based on experience, whereas since the marine oil engine of the power now required is practically new in the field, the designer is hampered by lack of reliable data. Ultimately, however, the oil engine will probably displace the steam engine, since the development of the former offers the possibility of a single motive power for all conditions, which will be reasonably efficient in the submerged condition. Modern chemistry is already in a fair way to provide the materials for supplying the necessary oxygen in such form as to meet the conditions imposed in a submarine. In the meantime the growing field of the oil engine, both afloat and ashore, will supply the experience necessary for the development of the largest powers apt to be used in the submarine.

The remaining important feature common to both designs is the employment of the electric drive for submerged work. The

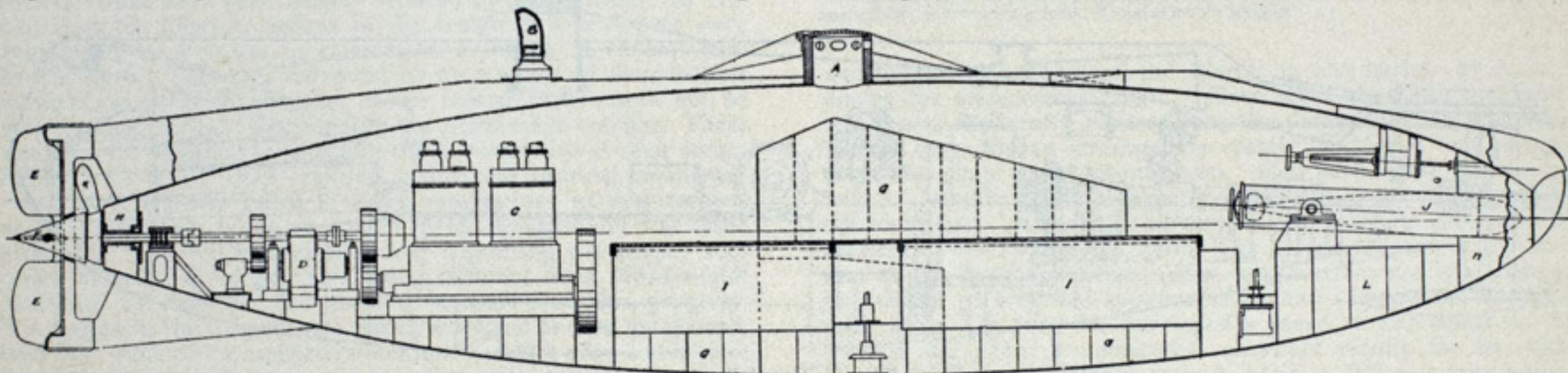


Fig. 8. The Fulton

A, conning tower; B, ventilator; C, gas engine; D, motor; E, steering rudder; F, diving; GG, ballast tanks; HH, trimming; II, battery; J, torpedo expulsion tube; K, propeller; L, gasoline tank.

moment about the center of gravity which also requires balancing. Its advantages, however, entirely justify its presence, since it not only serves as an instantly available element of safety in an emergency, but also permits the submarine to maintain the awash condition whether underway or not, without change of ballast or direct expenditure of power. In this condition, ready to dive instantly, presenting only the conning tower as a target, and herself commanding a complete view of the horizon, the submarine will do a great part of her work, even in the event of the perfection of observation apparatus for use when submerged. It is safe to conclude then that this feature has been permanently adopted.

CONTROL OF VERTICAL PLANE BY RUDDER ACTION.

The second characteristic, that of control in the vertical plane by rudder action only, is also fully justified by tactical and construction reasons. It is obvious that a change in depth can be effected in the least time and by the least expenditure of energy, if the vessel be moved in the direction of least resistance; in other words, if she be *steered* up and down *inclines* by altering the angle of her longitudinal axis to the horizon. In order to be effective, the turning moment used must be of considerable magnitude and under the most sensitive control, conditions best met by horizontal rudders, which have also the advantages of simplicity and economy of space, weight and power. Other things being equal, the rapidity with which a submarine can rise for observation and dive again is a direct measure of its efficiency, since its chance of escape from observation or projectiles is in inverse proportion to the period of exposure. As pointed out below, a loss in this quality may be justified when balanced by a corresponding gain in the equally important tactical feature of speed, but in no other way; hence it may fairly be concluded that this feature also has come to stay.

The correspondence between the French and American designs extends also in a general way to the most important construction feature—the power plant. For submerged work both have adopted the electric drive, and for surface work and recharging batteries, etc., both go back to the hydro-carbons, the

storage battery and motor are admirable in some respects, but exceedingly inadequate in others, the principal objection being the well-known one of excessive weight and space in proportion to the power developed. When it is stated that a weight of 370 lbs. per horse-power hour is a fair average for a suitable installation, it is readily seen that there is much room for improvement. Another disadvantage of the battery lies in the care and attention necessary for its safe operation after sensible deterioration has set in. The difficulty which takes the shape of abnormal behavior with respect to "gassing" may, under certain conditions, result in an explosion such as took place on the Fulton last spring and more recently on the Holland. Fortunately, however, this condition is not inevitable, and is susceptible of control when it does occur. There is no particular quarrel with the motor, except as to the difficulty in fitting it with a suitable propeller, and the battery bids fair to develop faster in the future than in the past, on account of the increasing demand for a light, compact battery for automobile use. Its continued use may thus be expected until the appearance, in practical form, of a development of a heat engine similar to that hinted at above.

DIFFERENCES OF FRENCH AND AMERICAN DESIGN.

The principal difference between the French and American designs lies in the choice made of dimensions and proportions which appears to be the direct result of different ideas as to the relative values of speed and maneuvering qualities. To attain the high surface speed desired, the French designers have been forced to adopt a considerable displacement, great length in proportion to beam, the double hull with large tank capacity, and incidentally the steam engine and multiple rudders. As compared with the Holland boats, the increase in surface speed is gained by a sacrifice of efficiency in three directions—first, as to simplicity, second as to the length of time necessary to pass from a cruising to the diving condition, and third as to the necessary period of exposure for conning tower observations. No exact data is available as to the minimum observation period required by the French boats, but their extensive use of the periscope indicates a relative inferiority in this respect. In shallow water at least

this result would naturally follow from the dimensions and form adopted, as it is probable that the rudders are then used to produce not only a turning moment but also a vertical thrust.

While the limit of surface speed for a given displacement has not yet been reached for either type, further material advances are most apt to be made by further increases in displacement. The limit to this process is not set by construction reasons, but by the probable use of the type, which for any one country is fixed by its geographical location and the nature of its coasts and harbors. For instance, a *submersible* of the Narval type and dimensions is for France not only a *defensive* but an *offensive* weapon, and the partial sacrifice of submarine qualities in the design is warranted by the possibilities for offensive use. The same boat transferred to America would become purely *defensive* and would not be so well adapted to the conditions here as is the American type. It is probable then that in countries situated like France, where the possible enemy possesses large ports and arsenals within easy striking distance, the *submersible* will eventually be increased in displacement to perhaps 300 tons, in order to obtain a vessel which shall be seaworthy in a large sense, habitable for considerable periods, self-supporting and capable of a fairly high sustained sea speed. Such a boat would be first and foremost a weapon of *offense* and only incidentally a weapon of *defense*, in which field its place would be taken by several smaller units. Whether these units should be of the *submersible* or pure *submarine* type depends upon the extent of the coast, the number of harbors, the internal water ways and the condition of the fixed defenses. As noted above, France has adopted for this purpose the *submarine* of the Perle type, a course which is probably justified by the small number of her harbors and her highly organized fixed defenses.

FOUR MAIN TYPES OF FUTURE SUBMARINES.

Turning now to the United States, her location with respect to possible enemies is such that there is no immediate prospect of the development of the large *submersible* into an *offensive* weapon; still the extent of her coasts, the number of her harbors, and the rudimentary character of her fixed defenses, renders this type preferable to the pure *submarine* for *defensive* purposes. The development of the best all-round boat to meet the conditions is likely here also to lead to some increase in total displacement, which, eventually however, will probably not exceed 200 tons. As compared with the larger *offensive submersible*, such a vessel would be less seaworthy and would have less surface speed, better maneuvering qualities and greater submerged endurance. The pure *submarine* would thus at first glance appear to be an undesirable type for the conditions prevailing in the United States, but this is only true so long as the sole aim is torpedo work. As a matter of fact, however, the usefulness of the submarine is not confined to this one function, as it affords today the best known means for the destruction of mine fields and cables and the reconnoitering of fortified harbors. The objective being far removed, it is essential that the dimensions and weight of this type of vessel be kept at the lowest limit in order to admit of transportation by battleships, armored cruisers and the larger class of scouts. In such a vessel some armament would be desirable for attack upon stationary shipping, dry docks, etc., but this feature should be subordinated to the features necessary for efficient bottom work. By taking full advantage of the latest developments in diving apparatus, all the essential features, including efficient signalling apparatus, could today be combined in a maximum length of 35 ft. and a maximum displacement of 25 tons. This appears to be the only possible guise in which the pure *submarine* may play an *offensive* role, and even here, in the author's opinion, means for recharging batteries are desirable and justifiable, as scout work might require a considerable radius of action.

To sum up it appears that the submarine boats of the near future will naturally divide themselves into four types and two main groups, to conform to the different conditions in the different maritime countries. The first group would be suitable for many of the European countries, and would include the large *offensive submersible*, self-supporting, with auxiliary bottom working features, and the small *defensive submarine* for torpedo work only. The second group, suitable for the United States and similarly situated countries, would include the small *offensive* ground-working *submarine* or *submersible* (with auxiliary armament) and the medium-sized *defensive submersible* for torpedo work only. It appears, further, that the *submarine* qualities of the modern boats are based on sound principles, and that the future development of the four different types within the limiting displacement of each must be along the present lines, and in the direction of improvement in the tactical qualities of speed and practical radius of action. As pointed out above, improvements in these respects are largely dependent upon the general improvement of the power installations and as compared with the corresponding feature in the main objective, the battleship, the improvement in the submarine bids fair to be the more rapid.

In conclusion, it is proper to state that the author cannot vouch for the accuracy of the data given above with regard to the modern French boats, although it is believed to be substantially correct. All available sources have been freely drawn on for the data contained in the historical review, but the author is especially indebted in that respect to the admirable work of Lieut. Delpeuel of the French Navy, entitled "La Navigation Sous-Marine a

travers les Siecles." No apology is offered for the lack of the detailed data so desirable in a communication to a technical society as, for obvious business reasons, it has been necessary to exclude the consideration or description of details from this paper.

MR. SPEAR'S PAPER DISCUSSED.

Mr. Lewis Nixon, president of the United States Ship Building Co., discussed Mr. Spear's paper with great vigor. He regarded it as a most valuable contribution to the literature upon the subject. Mr. Nixon said that one of the great drawbacks in the development of the submarine had been the fact that until a few years ago no dependence could be placed upon the hydro-carbon engine. When Mr. Holland first approached him to build the Plunger he declined to do so on the ground that he did not want to have anything to do with designing a vessel which contemplated three engines and a boiler in a place where men had to live. Later when the hydro-carbon engine was more developed the submarine boat Holland was started.

"Speed," said Mr. Nixon, "I do not regard as necessary in a submarine. It is essentially a vessel for defense and 8 knots on the surface and 7 knots beneath it is, in my opinion, very fast. To gain greater speed there would have to be sacrifice of maneuvering power. The submarine must be small and of such dimensions as to go under the bottom of a ship, even in shallow water. I don't believe in the submersible boat—that is like making the vessel a Jack of all trades. When Mr. Whitney was secretary of the navy he proposed a semi-submerged armor clad with great powers of resisting punishment. Something might come of the development of such a type. I believe that this society should thank Mr. Spear for contributing an article of definite value in a field of endeavor which has been dampened by those who should have the greatest interest in quickening development in it."

Prof. Hovgaard discussed the paper at some length. He believed that future development might be looked for in motive power. He rather questioned the use of the gasoline engine, owing to the fact that it was not free from the suspicion of danger. He thought it was also a drawback to an explosive engine that it could not be run at a great number of revolutions. He had also been told that it could not be reversed without the use of an electric motor. He thought it likely also that greater displacement and greater power would be required in the submarine in the future. He did not believe that the steam engine had been given a fair trial in the submarine in the United States and said that latterly one of the French submarines had made a trip from Cherbourg to Havre, a distance of 142 miles, in twenty-two hours. While the personnel suffered somewhat from the heat, the trip was, nevertheless, successfully made. He could not see the essential difference in requirements between the French offensive submarine, which is intended to attack the coast of England, and the United States defensive submarine, which is intended to operate outside of United States harbors. One would have to be just as seaworthy as the other. He predicted that the submarine would reach as high as 300 tons displacement and held them at present to be in an experimental stage, chiefly valuable to small countries whose principal desire is defense.

"I congratulate the friends of the submarine boats," said Admiral Bowles when he rose to speak, "upon the accession to their ranks of so able an exponent of the value of the submarine. They can now regard with greater equanimity that official dampening of ardor to which reference has been made. But I confess personally to be in a complete as to the difference between submarine and submersible and am simply appalled to learn that there are two kinds of four sub-divisions—the submarine and submersible and offensive submarine and defensive submersible. These things should not be permitted to multiply so fast. I think it should also be brought to the attention of the war department that the defenses of our coast are of the most rudimentary character. But the submarines are, in a measure, a success, for they possess undoubted moral value. I remember when the war with Spain was in its incipient stages a Spanish war vessel visited New York harbor and fear was expressed by some that Fenians (I am not vouching for exact details in this narrative), would get hold of our solitary submarine boat and proceed to blow the warship up. I was called upon to ascertain where the submarine was with a view to having surveillance exercised over her. I told them that I would call up Nixon and see where she was; but my services as an amateur detective were dispensed with upon that remark. I know that surveillance was exercised over this boat at a time when she could not possibly have done any damage whatever."

Mr. Francis G. Hall, Jr., suggested the advisability of equipping a submarine with an engine to use kerosene as a fuel, instead of gasoline, saying that he had been informed that it would be possible to generate 160 H. P. in such an engine for a submarine.

Mr. Spear replied briefly to those who had commented upon his paper. He thanked Mr. Nixon for his remarks and agreed with his conclusions that extra speed in a submarine would have no practical use. In reply to Admiral Bowles he insisted that if the admiral did not know the difference between submersible and submarine, which everyone else knew, it was to be ascribed to his opposition in general to that type of vessel. He begged to repeat the charge, that with possibly one or two exceptions, the coast defenses of the United States are of a most rudimentary character.

MR. GEORGE CROUSE COOK.

George Crouse Cook received the first diploma issued by the Webb Academy of Ship Builders, graduating with the first class, that of 1897. He was also a student of engineering and naval architecture at the Glasgow University, Glasgow, Scotland, for two years and in his senior year he was awarded by the university the naval architecture honors, senior class, for the highest work in advanced theoretical lines. By passing the civil service examinations he was appointed to a position in the navy department at the Washington navy yard. He resigned this, however, to accept a position with the William Cramp & Sons Co., Philadelphia, where he remained for two years, performing general calculating and drafting on merchant and naval work. He then accepted a position with Howaldtswerke, Kiel, Germany, where he had charge of the design and construction of three vessels. For some time past he has been established as a naval architect in New York city. He is also known as the instructor of naval architecture at the New York Nautical college. He also lectures on ship building for the board of education of New York.

**Mr. George Crouse Cook.****BENDING STRAINS ON DAMAGED SHIPS.**

Mr. George Crouse Cook's paper on "Longitudinal Bending Stress on Damaged Ships" served as an introduction for him to the society. Mr. Cook is among the youngest of the members. As with most such papers there was no discussion, but Admiral Bowles, who was in the chair, took occasion to refer to the labor involved in such contributions while calling for the usual vote of thanks. The paper is divided into two sections, which treat of the calculation of longitudinal stress in the abstract, and then of the particular application and results on certain vessels in the damaged and intact conditions. In the first section the author states the general principles upon which the work of calculating longitudinal stress is founded, and then presents certain mathematical demonstrations in support of the stated theory. Following this he shows a system of standardization of the stress diagram, by which a direct comparison of the resulting stress on entirely different types of vessel can be made. In addition a standardization of the curve of weights is presented, which enables this laborious section of the work to be rapidly overcome.

In the second section of the paper, the results of a series of stress calculations, executed by the methods described at first, are presented for a series of vessels marked A, B, C, D and E, in the intact and variously damaged conditions. The vessels range from a rectangular coal barge to the 500-ft. Atlantic liner, and therefore, the final conclusions have a fair justification. The first vessel taken in illustration of the text is a rectangular wooden coal barge of uniform section and constant distribution of weight. The stress on this vessel is then calculated in four conditions—when the vessel is intact and floating in still water; when bilged and in still water; when it is floating intact across the hollow of a wave; when bilged on this same wave. The resulting figures of these calculations show that the unequal distribution of the buoyancy, caused by bilging a compartment of the vessel, develops high stress in the vessel.

This work is then duplicated on a tug boat, a large steam yacht, an oil steamer and a large liner. In the case of the tug and the yacht, where the weight of the hull and machinery make up the total displacement, and the machinery is placed amidships, the result of the bilged compartment is to increase the stress greatly. In the case of the yacht, where the percentage of the whole weight taken up by the engines is quite large, the result is most serious, and in one instance shows an increase of 718 per cent. due to the possible bilged condition. In the cases shown by the larger vessels, these results are not as great a percentage of the whole, and may therefore be neglected in general consideration.

Having shown the seriousness of the stress on these light vessels, when damaged, the author draws the conclusion that this question of stress and strength should receive the same attention with reserve buoyancy and stability in like conditions, as the reserve buoyancy gained by watertight compartments may so accent the stress on the vessel that it will break amidship and be totally destroyed, while with this stress duly provided for the safety of vessels will be greatly advanced.

Owing to the lateness of the hour Mr. F. W. Belknap's paper upon "Measurement Rules for Yachts, With Special Reference to Racing Conditions," was not read except by title.

It was announced that the author of the prize competition paper upon "The Balancing of Valve Gears" was Mr. Luther D. Lovekin, chief engineer draughtsman of the New York Ship Building Co., Camden N. J. The prize of \$50 was accordingly awarded to him. The paper was read only by title owing to lack of time.

Mr. Nixon moved that a vote of thanks be given to President Griscom for the interest which he manifested in the society by giving so much of his time to it when so many other demands were pressing upon him.

"And who has added dignity, importance and value to our gatherings," put in Admiral Bowles, in seconding the motion.

It was carried and the meeting stood adjourned for one year.

BANQUET OF NAVAL ARCHITECTS AND ENGINEERS.

On Friday evening the serious discussion of technical papers had been given up for good-fellowship at a banquet at Delmonico's. It was generally agreed that the attendance at this year's meeting had been the largest in the history of the society. Probably 275 members had attended one or more of the several sessions. Some of the old heads, among them Admiral Melville, were missing, but there was nevertheless a more general discussion of the papers than at any time in the past. The banquet was also very well attended. President Griscom was the toastmaster, and sitting close to him at the main table were Rear Admiral Bowles, James J. Hill of the Great Northern Railway, Myron T. Herrick of Cleveland, Lewis Nixon, Charles H. Haswell, who was the first engineer-in-chief of the United States navy, Col. Alexander McClure and P. A. B. Widener of Philadelphia, as well as several members of the council of the society. Toasts were responded to by Rear Admiral Bowles, James J. Hill, Anthony A. Rawlins of the Atlantic Mutual Insurance Co., Col. Alexander McClure, Chief Engineer J. A. B. Smith of the Brooklyn navy yard, Myron T. Herrick, Hon. Frederick Storm and Lewis Nixon. Mr. Hill spoke principally of the development of trade with the Orient and his confidence in the ultimate upbuilding of a great merchant marine on the Pacific. Nearly all of the addresses otherwise pertained to the demand for a sea-going merchant marine and the necessity of continuing the agitation along that line that has been quite vigorous in the past few years. As on previous occasions, there was the same regret that congress has not seen fit to render to the merchant marine the assistance that is necessary to give it a start under disadvantages, but there was a general expression of satisfaction over what has been accomplished without assistance and confidence in the future of our shipping, even though nothing may be done by government to advance its progress. It was the general sentiment that providence has made ample provision in this country for the construction of ships to trade with the world and that we must certainly be expected to soon provide intelligence and skill to meet these advantages.

Mr. Griscom was highly commended at the close of the banquet for giving up so much of his valuable time to the society and a most earnest vote of thanks extended to Secretary Capps.

TRIP TO BIG CAMDEN SHIP YARD.

The works of the New York Ship Building Co., a ship yard at Camden, N. J., that has several times been described in these columns, and which is a plant probably unequaled elsewhere in the world as regards modern equipment, was visited by the members of the Society of Naval Architects and Marine Engineers to the number of about 250 on Saturday following the New York meeting. Mr. H. G. Morse, who is at the head of this great establishment, had made admirable arrangements for his guests. A special train was provided, leaving New York early enough to reach the ship yard about noon. A sumptuous lunch was in waiting and was partaken of before the visitors were divided up into groups to go through the yard. The executive force of the ship building company acted as a reception committee. A blue ribbon was their distinguishing mark and they were on hand everywhere to give information. With six large

merchant ships under way—two of them of 600 ft. length, two of 505 ft. and two oil tankers of smaller dimensions—there was much in this yard to repay everybody who had made the trip. About 3,400 men are now employed at these works. Of course, the visitors were most interested in the radical departure inaugurated at Camden in the method of construction—everything done on the template or wooden pattern system. There is practically no template work at other yards of the seaboard and it is not carried on in the yards of the great lakes to anything like the extent that prevails in the Camden works. The visitors had full three hours in which to go over the ship yard before return of the train to New York.

**Henry G. Morse.**

AROUND THE GREAT LAKES.

The Cleveland & Buffalo Line expects to spend \$30,000 in repairing the City of Erie and City of Buffalo during the winter. Water signals on the Detroit river will not register from this time until the close of navigation greater depth than 18 ft. 2 in. at the Limekilns.

Johnson Bros. of Ferrysburg, Mich., will build a steel tug of 68-ft. length and 17-ft. beam for the Graham & Morton Transportation Co. of Chicago.

It was quite evident for some time past that the combination of Lake Michigan passenger boats so much talked of had too much newspaper prominence to amount to much. It is now announced that "the deal is off."

General passenger agent Herman of the Cleveland & Buffalo Transit Co. announces that steamers of that company will make the last trip of the season from Cleveland Friday, Nov. 28, and from Buffalo Saturday, Nov. 29.

The Empire Ship Building Co., Buffalo, has received an order to practically rebuild the steamer C. W. Elphicke. The steamer will have a new steel deck and frames. The company will also place steel decks on the Pontiac and Frontenac.

The Graham & Morton Line has secured the steamer Argo from the A. Booth Packing Co. The Argo was built a year or more ago by the Craigs at Toledo. A new upper deck is to be added to her, giving the steamer a capacity of 100 staterooms.

The fire that burned one of the Wisconsin Central ore docks at Ashland Saturday anticipated the proposed demolition of the dock a few weeks later. It was to have been torn down and rebuilt at the close of navigation. The dock was fifteen years old and quite rotten. Timber is now on the ground for the new dock. Little of the old timber was to be used in the new structure.

Sault Ste. Marie has definitely taken up the movement to celebrate the semi-centennial anniversary of the breaking of ground for the construction of the first canal. A committee has been appointed on transportation and it is likely that a delegation will be sent to Washington during the winter to urge congress to officially act in the matter.

The Great Lakes & St. Lawrence River Transportation Co. (Wolvin syndicate) has closed its operations for the year. While no statement has been made regarding the net result of the season's business it is looked upon as satisfactory. It is, of course, expected that the showing will be even better when the new vessels, which are now building, will be placed upon the line.

A decision affirming the action of the collector at Ogdensburg, in assessing duty for repairs made on the steamer Hecla at Kingston, Ont., has been announced by the board of classification of the United States general appraisers. The collector assessed a duty of 50 per cent ad valorem on the cost of the repairs and the George Hall Coal Co. protested, pleading that there was no American dockyard on Lake Ontario big enough for the Hecla.

"I will be glad when the present season is over," said Mr. Thomas Adams, vessel owner of Detroit. "There is enough work for vessels but the present low freight rates render it pretty hard to make the business pay. However, I live in hopes as it looks promising for next year. They are building ships on the great lakes without end, but it doesn't worry me, as the immense resources of the northwest will give them something to do. In my early days about all that ever came from there were skins and furs. Think of what comes from there now."

The Jenks Ship Building Co. is preparing to lay the keel for the new passenger steamer for the Michigan Steamship Co. which is to operate a service between New Haven and Chicago. The steamer will be 275 ft. long, 38 ft. beam and 22 ft. 8 in. deep. There will be four decks, three of steel, and the upper, or hurricane deck, of wood. The main deck will be for freight and the next two decks will be partitioned off into staterooms. The engines will be triple-expansion, with cylinders of 21, 34 and 56 in.

diameter and 30-in. stroke. Steam will be furnished by four Scotch boilers, 13½ ft. in diameter and 12 ft. long and each will be allowed 200 lbs. pressure. The steamer will be lighted throughout with electricity.

Extended improvements are being made in the plant of the Detroit Ship Building Co. It is expected that by the first of the year the shops will be very complete. The structural work on the first big building is now complete and the walls are being bricked in. It is almost ready for the roof. The new shop is 172 ft. long, 49 ft. wide and 40 ft. high. The roof truss has been made strong enough to carry the two lower floors, thus leaving a clear space for big work. The ground floor will be used for a storeroom, superintendent's office, scales, screw-cutting machinery and blacksmith shop. The second floor will be used for tool rooms and pattern shop. One half of the third floor will be occupied by the engineers' draughting office and the remainder for lumber storage and light patterns. The new foundry building will be 151 by 75 ft., equipped with electric crane. There will also be two electric travelers commanding the entire floor space. C. B. Calder, general superintendent of the company, designed the improvements.

The protest filed by the captain of the steamer Robert Wallace tells briefly of the loss of that vessel on Lake Superior several days ago. Capt. J. M. Nicholson and the crew say that after running about an hour and fifty minutes from Duluth on the regular course for Devil island the wheel struck heavily on some sunken obstruction, bringing the engine up-standing and jarring the whole ship. Water began immediately to pour in and around the stern post in such quantities that the ballast pump, syphon and pony pump were unable to care for it. As it was seen that the vessel was sinking, the schooner Ashland, in tow, was got alongside and the course directed for Two Harbors. The crew succeeded in keeping the engine going for fifty minutes but the steamer was settling fast and the lines were accordingly cast off from the schooner. A tug picked the schooner up about a half mile from Two Harbors and towed it into port. The crew then returned on the tug to look after the steamer but it had entirely disappeared. As it sank in 300 ft. of water it was regarded as a total loss. The Wallace was loaded with ore.

ANOTHER PASSENGER STEAMER.

The Manitowoc Dry Dock Co. has secured a contract for a passenger steamer for L. A. Cartier and others of Ashland, Wis. The dimensions are 112 ft. long, 22 ft. beam and 10 ft. molded depth. It is to be built of oak and sheathed with steel. The power is to consist of a triple-expansion engine and Scotch boiler, the engine to be made by the Montague Iron Works and the boiler to be made by the Johnson Iron Works. The boat is to be completely equipped with electric lights and to resemble closely the larger passenger steamers now running on the lakes. In view of the conditions under which she will be run a guaranteed speed of 16 miles per hour was necessary.

MR. M. J. LAWRENCE BUYS THE SATANELLA.

Mr. M. J. Lawrence of the Ohio Farmer of Cleveland has purchased the yacht Satanella from Perry Belmont of New York. The Satanella was formerly the Golden Fleece and was built at Cowes, England, in 1880. She is an auxiliary sail, composite-built screw yacht of the following dimensions: Length, 119 ft. 4 in.; breadth, 22 ft. 5 in.; depth, 12 ft. 9 in. She is equipped with a compound engine with cylinders 13½ and 22 in. diameter and stroke of 13 in. She has one cylindrical return-tube boiler allowed a working pressure of 80 lbs. The yacht is now being fitted out in New York for a six months' cruise in the West Indies. Mr. and Mrs. Lawrence contemplate visiting the entire group of islands.

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NEWS MATTERS FROM THE HEAD OF THE LAKES.

Duluth, Minn., Nov. 25.—Surprising as it may seem, a considerable amount of northwest Canada wheat has been coming to Duluth for shipment east; surprising from the fact that Canada has two Lake Superior ports still open, and from which shipments are being made. It is not surprising to know that large amounts of this wheat will be received at Duluth during the winter, but that the Canadian roads are so overwhelmed by traffic that they are forced to give up the long haul on their own wheat at this season is a remarkable admission. It is becoming evident that it will be a long time before the two Canadian roads to Lake Superior will be able to acquire facilities to handle all the grain traffic that will year by year press on them, increasing with wonderful rapidity.

Mild weather has permitted of very active operations of the iron mines thus far, although a complete shut down on account of frost at any time after Nov. 15 would not be especially surprising in this region. At the Fayal mine, for instance, which has already shipped about 1,850,000 tons, they are still urging the output to the limit. A few of the miners are already stocking to some extent for another year and in many instances orders have been received to push stock-piling work for 1903. It is therefore thought that a 30,000,000-ton output is within the probabilities for 1903. Many of the ore men at this end of the line expect a higher price for ore another year, as well as a better freight rate, and look for an additional charge for ore delivered at Lake Erie of at least 50 to 75 cents a ton, possibly more. It is probable, too, that the large differential against Mesabi ores will be lessened. It is now out of all proportion and should be changed in justice to the mining contingent.

There is no probability that the Duluth & Iron Range road will carry out this winter the very extensive harbor works it has planned, which include the building of what will practically be a new harbor on the northeast side of the lighthouse at Two Har-

bors. It will probably improve its dock facilities for both lumber and ore, the former especially. There is absolutely no room inside the Two Harbors breakwater for any more piers. In fact those now there make the maneuvering of large ships a difficult undertaking in any weather. The 550-ft. ships that are talked of for the Pittsburg Steamship Co. will not be able to get under Two Harbors ore chutes unless everything is favorable.

The new Great Northern ore dock will contain 160 ore pockets each of 250 tons capacity, making the total capacity of the dock about 40,000 tons. It will be of the same height as the No. 2 dock of the same company, which is the highest on the lakes, 73 ft.

Considerable Illinois soft coal is coming to the head of the lakes, all rail, and it is probable that this business will be continued all winter. The supply of soft coal coming up by water is not expected to carry steam users through the winter.

ANNUAL REPORT OF LIFE SAVING SERVICE.

The annual report of the superintendent of the life saving service is at hand. A very full summary of its contents will probably appear in these columns later on. The great lakes appear to have had their share of the season's disasters. On Lakes Erie and Ontario the number of disasters was sixty, involving vessels valued at \$219,685, of which \$22,605 was loss. On Lakes Huron and Superior the number of disasters was eighty-four, involving vessels valued at \$2,688,885, of which \$315,330 was loss. Lake Michigan had the greatest number of disasters, totaling 108 and resulting in a loss of \$176,415. The report goes thoroughly into the disaster which overtook the life saving crew of the Monomoy station in endeavoring to rescue William Mack of Cleveland and others. The net expenditure for the maintenance of the service during the year was \$1,654,393.96.

ELIAS GUNNELL,
PRESIDENT.THOS. J. PRINDIVILLE,
VICE-PRESIDENT.L. E. GEER,
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V. Waring N.Y.

KRUPP IS DEAD.

Frederick Alfred Krupp, the sole owner of the gigantic industries which bear the general name of Krupp, died very suddenly of apoplexy at his villa near Essen on Saturday last. He was only forty-six years old, and while he was of the third generation of Krupps it was he who vastly extended the group of Krupp industries though his father had already made the name famous. Three generations of Krupps expanded a little forge at Essen, employing nine men, into a ramified series of industries employing 45,000 men. Unlike his father he took no interest whatever in the technical side of his business and rarely visited the works. He managed them through a board of directors by letters and telegrams. In his endeavor to ameliorate the conditions of the working classes he was almost socialistic. He built houses of the most approved pattern for his workmen and rented them at a reasonable rate. No two houses were built alike. He had convalescent hospitals and orphanages, and while the workmen maintained a pension fund through fees, Krupp's own contributions to it were of a most enormous character. It was as a gun maker that Krupp was principally known and Krupp cannon frowned from the fortresses of every country save France. Krupp, like his father before him, would not sell ordnance to any country which he held to be the hereditary foe of his own. Krupp, however, resented the title of cannon king, maintaining that half of all the output of his works was civilizing products, meaning structural steel, ship plates and railway material. There is no male lineal descendant left of the first Krupp now. It is understood, however, that Arthur Krupp a cousin, will be the head of the management. Briefly the history of the Krupp enterprises is this: Frederick Krupp started a little forge with two workmen in 1817. He died in 1826, leaving the business to his son Alfred, together with certain secrets in the preparation of steel. Alfred continued the business, which grew gradually, but it was really a small business still when the Crystal palace exposition was held in 1851. At that time he made a brave display of his steel and guns, and as a result received many orders from various governments for armament. As an instance, the Krupps have supplied Russia with 30,000 guns. Alfred Krupp died in 1887. The son, Frederick Alfred, found the business well established but he decided to vastly expand its operations. He bought outright coal fields in Germany, ore deposits in Spain, built his own railways and established his own ship yards and so largely increased his subsidiary companies that he became, by far, the

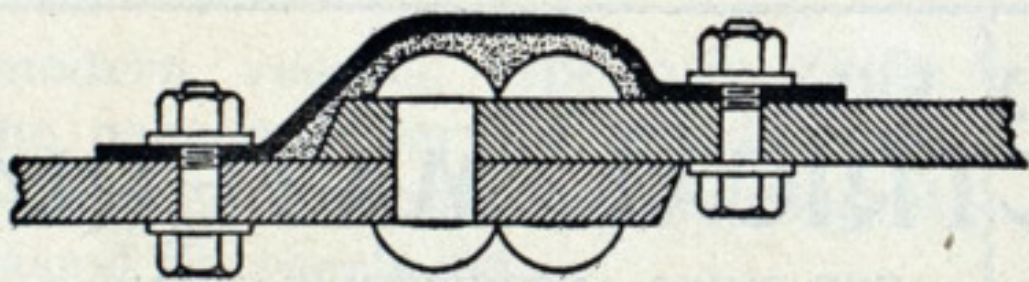
largest employer of labor in Germany and undoubtedly the largest single employer of labor in the world. Herr Krupp was undoubtedly a great man.

LICENSED STEAMBOAT OFFICERS.

Editor Marine Review:—In your issue of Oct. 23, you published an opinion of the United States attorney general under the title "Licensed Steamboat Officers." in reference to the question whether local inspectors can require witnesses to answer in proceedings under section 4,449 of the revised statutes. Few people read carefully an opinion of this kind to distinguish just what was decided. I beg to suggest what is decided in this opinion, first quoting from it, after the preliminary remarks by the attorney general, as follows: "Passing on, then, from this review of the policy and general meaning of the law, we take up the *exact question* presented as to the right of licensed officer to refuse to answer questions put to him in the course of a regular investigation by a board of inspectors, on the ground that he may thereby subject himself to *penalty by way of revocation or suspension of his license.*" I submit that in the late investigation on the great lakes the refusals to answer were based upon stronger grounds than the grounds "he may thereby subject himself to penalty by way of revocation or suspension of his license." The further reason was assigned that the witness feared that he might by his answer bring himself into public disgrace and possible criminal liability.

Now, quoting from the decision further on: "That a witness may refuse to answer a question where it *reasonably* appears that such answer will have a tendency to expose him to a penal liability or to any kind of punishment, or to a criminal charge, is well settled and needs no citation of authorities. It has also been held that it is the privilege of a witness to refuse to answer questions which may have a tendency to expose him to a penalty or forfeiture. (1 Greenleaf on evidence, section 453; Story Eq. Pl., section 607, 846; Johnson vs. Donaldson, 18 Blatch., 287; and see cases cited in 29 AM. & Eng. Enc., p. 836.)" And then again in the same paragraph as follows: "The words 'penal' and 'penalty' have been used in various senses. Strictly and primarily, they denote punishment, whether corporeal or pecuniary, imposed and enforced by the state, for a crime or offense against its laws. But they are commonly used as including an extraordinary liability to which the law subjects a wrongdoer in favor of the person

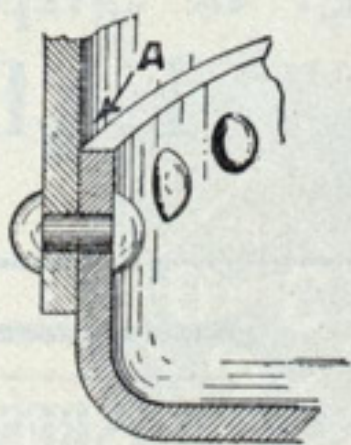
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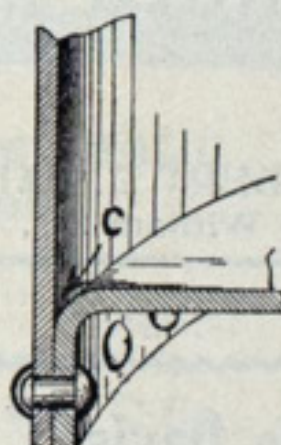
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Smooth-On Compound Iron Cement No. 1 was used for work illustrated by Cut No. 2. A layer of cement was placed at seam C, its entire length, so as to make a fillet around the inside of the joint between the head and shell—allowed to stand 12 hours to metalize—and made the seam perfectly tight.

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VREELAND TOMPKINS, CHEMIST AND MANAGER.

wronged, not limited to the damages suffered. (Huntington vs. Attrill, 146 U. S. 657, and cases cited therein.)" The attorney general holds, however, that the revocation of a license is not such a penalty as is referred to in the decision quoted. Quoting again from the decision: "It might, of course, happen, as suggested by the solicitor of the treasury in his opinion dated June 19, 1902, that on the trial of a licensed officer before the board for a violation of section 4,449, questions might be put, which, if answered, would disclose facts showing that the officer had incurred a penal liability for which he was liable to indictment and punishment, as under section 4,437. In such a case the officer would be entitled to his refusal to answer." The attorney general goes on to say that in his communication he has nothing to do with anything except where the refusal to answer is based solely on the ground of fear that he might have his license revoked, or suspended, and it is his opinion that such penalty is not of the kind referred to in the decision, allowing one to refuse to answer for fear it will subject him to a penalty.

The matter of what penalty would and what penalty would not come within the decision of the supreme court of the United States, and would entitle one to refuse to answer, is a question upon which lawyers might disagree, and whether the penalty of revoking or suspending license is such a penalty has not been decided by the court.

It is plain that the attorney general has not passed upon the real question that was before the local inspectors, and that if he had passed upon the questions before the local inspectors he would have justified the witnesses in refusing to answer. As to what the court would say of the right of a licensed officer to refuse to answer the questions on the ground solely of fear that he might subject himself to a revocation of his license we are not much more advised than we were before your publication of this decision. The solicitor of the treasury gives his opinion one way, the attorney general gives an opinion the other way; neither answers the query we had before the local inspectors last summer, and nobody can tell whether the United States supreme court would agree with the solicitor of the treasury or with the attorney general on the subject.

It certainly is desirable that employers of licensed men, as well as inspectors, should know as much as it is possible to know of what the law is in this respect. It is likewise desirable that the same persons should not be misled, and think that they know the law to be one way, when it may possibly, and probably, be the other way. It is not desirable to be deluded with the idea of knowing something that we don't know; and it is for this reason that I have respectfully submitted this letter for publication.

Cleveland, Nov. 22, 1902.

ORESTES C. PINNEY.

District office managers of the Westinghouse Electric & Mfg. Co., representing all the principal cities of the United States, spent the past week in their usual annual visit to the works and offices of that company at East Pittsburgh. On the evening of Nov. 19 a very enjoyable dinner, in honor of the visitors, was given at the Duquesne Club, at which the engineers and executive officers of the company were also present.

ITEMS OF GENERAL INTEREST.

The Waterbury Brass & Copper Co., 122-130 Center street, New York, report October sales as being far in excess of any month in the company's history.

J. C. Roberts, marine broker, Maritime building, New York, is looking for a sloop yacht of from 40 to 45 ft. length, 14 to 16 ft. beam, and draught not to exceed 3 ft.

Arthur Masters, naval architect, 29 Broadway, New York, is designing an auxiliary schooner yacht for a New York yachtsman, to be 70 ft. on water line, 23 ft. beam and 6 ft. draught. The auxiliary power will be furnished either by a gasoline or kerosene engine, yet to be decided.

Charles Parsons who has long been engaged in railroad mechanical work and in the sale of engineering and railroad supplies, is now connected with the Chicago Pneumatic Tool Co. and will travel in the interests of their tools. Mr. Parsons was for thirteen years with the railway lines now comprising the Erie road and was also for a number of years with the Tiffany Refrigerator Car Co., so that he is familiar with mechanical work.

J. W. Willard, naval architect of 32 Broadway, New York, recently designed a steam yacht to be built of wood and to be of the following dimensions: Length, 116 ft.; beam, 17 ft.; depth, 9 ft. The vessel is to be built by the Marine Construction & Dry Dock Co. of Mariner Harbor, Staten island. She will have Almy water-tube boilers. Her engines will be built by Brown & Miller of Jersey City. Mr. Willard also has on the boards two 200-ft. steel ferry boats for a New York company and a wooden oil barge, besides a large steamer for the Peoples Line, to ply on the Hudson between New York and Albany.

Vessels classed and rated recently by the American Bureau of Shipping in the Record of American and Foreign Shipping are: American screw steamers Excelsior and New Jersey; American schooners Stanley H. Minor, Celeste, City of Georgetown and F. & T. Lupton; American three-masted schooners Edwina, Anna Pendleton, Gertrude L. Trundy and Woodward Abrahams; British three-masted schooner Laura C.; British half-brig Marcani; British bark Cedar Croft; British barkentine Peerless and Swedish bark Australia.

In the dash of naval vessels from Hampton Roads last week to Culebra light the race was won by the cruiser Cincinnati which overcame a thirty-five mile handicap. Under orders of the navy department five of the ships lined up for the start—the Alabama, the Kearsarge, the Massachusetts, the Indiana and the Machias. The Machias is a gunboat of 1,000 tons displacement. The others are battleships. Thirty-five miles behind them was the protected cruiser Cincinnati. Of the battleships the Alabama took the lead and held it, though it was disputed for a long time by the Kearsarge. Both of these battleships represent the latest type of vessels of that class, the Alabama being a product of the Cramp yard and the Kearsarge that of the Newport News yard. The cruiser Cincinnati hove into sight on the second day of the race and gained steadily on her rival, passing her finally and holding the lead until the end of the race.

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ELECTRICAL MATERIAL

FOR SHIPS AND FORTIFICATIONS.

The Davis Boiler Feeding System

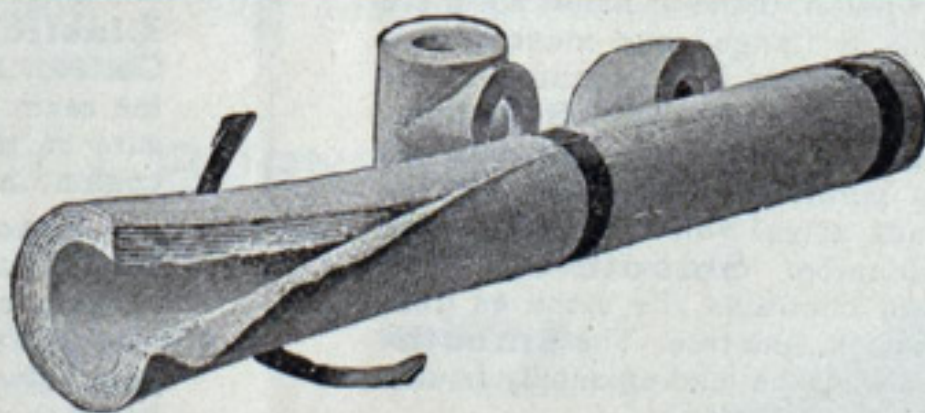
maintains a constant water
level in all types of boilers.

Prevents explosions,
Prevents low water,
Prevents high water,
Prevents burnt sheets or flues,
Prevents priming of engine
cylinders,
Saves fuel.

WRITE FOR CATALOGUE.

Moore & Handley Hardware Co.,
BIRMINGHAM, ALA.

ASBESTO-SPONGE FELTED SECTIONAL PIPE COVERING



H. W. JOHNS-MANVILLE CO.

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MILWAUKEE BOSTON CLEVELAND
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MADE from pure long-fibred Asbestos and a small amount of granulated Sponge. Competitive tests have proven beyond a doubt that it is a most superior insulator. As it is very elastic, it is especially valuable where there is danger from motion and vibration. It is adapted for the highest steam pressure.

Sending for our LEAFLET A 2 or one of our Representatives is like depositing money in the bank.